Soil Associations and Land Classification for Irrigation, San Juan County

Agricultural Experiment Station
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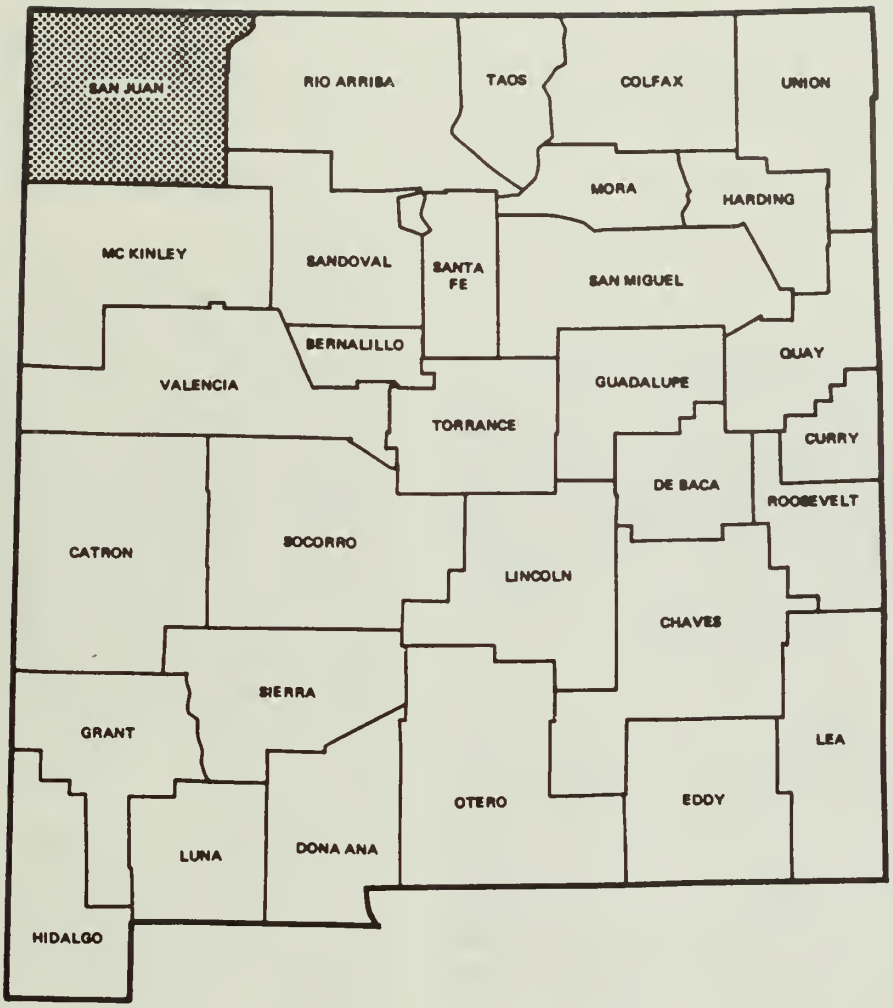

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This is a revision of Research Report 161, incorporating the most recently available knowledge of soils of the area.

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SUMMARY

San Juan County has a total land area of about 3,530,200 acres. Approximately 37 percent, or about 1,322,300 acres, is considered suitable for irrigation. Of this total estimated acreage of irrigable land, about 49,000 acres are now irrigated. Therefore, a large acreage of land remains that is suitable for irrigation. The potential for expanding irrigation is limited by a lack of water and by economic restrictions rather than by a shortage of suitable soils. Of the land classified as suitable for irrigation, approximately 83,714 acres are in irrigation land class 1; 583,144 acres in class 2; 375,255 acres in class 3; and 280,189 acres in class 4. The remaining 2,207,898 acres in the county are in land class 6, which is not suitable for irrigation.

The data are organized and presented on the basis of the 18 soil associations shown on the general soil map (see figure 1). The irrigation land classification map (figure 2) shows the approximate distribution of irrigation land classes in San Juan County. Only the dominant land classes are shown in each of the areas outlined.

The soil associations differ significantly in suitability for other uses just as they do in suitability for irrigation. For example, the use of land in the Travessilla-Rock Land association (No. 14) is generally restricted to recreation, grazing and habitat for wildlife, and grazing for livestock. In contrast, the Werlow-Fruitland-Turley association (No. 2) is suitable for many uses including irrigated farming, range, urban and industrial sites, and recreation, and it also has habitat for many species of wildlife. The high mountainous land in the Vamer-Rock Land association (No. 18) includes the principal timber-producing soils in the county. In addition to timber production, this association is used for grazing and as habitat for many species of wildlife, and it offers many recreational opportunities.

Engineering classification of these soils has also been provided to facilitate use of the soil association information by engineers and others acquainted with these groupings. Information relative to the suitability of the soils for a variety of engineering uses and specific factors limiting their use is also given in the engineering section.

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Soil Associations and Land Classification for Irrigation, San Juan County

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An essential for planning the best possible use of land and water resources is information on the capability of soils for many uses, present and potential. One such land use is irrigated agriculture, and the many soils occurring within New Mexico should be evaluated for this land use, especially since there is interest in the expansion of irrigation in the state. The water required for the new irrigated land, if expansion should occur, would be developed locally, transferred from other sections of the state, or brought in from distant sources.

The primary purpose of this report is to present information on the suitability of soils in San Juan County for irrigation. The acreage, general location, and relative capability of the soils for such use are given. This information can be used in appraising the value or suitability of large tracts of land for irrigation. Only soils capable of high productivity under sustained irrigation can be expected to provide a satisfactory income for farm operators. Obviously, limited or expensive irrigation water should be used on soils that are the most productive and have the fewest limitations. The extent, location, and relative suitability of land for irrigation in San Juan County are presented in the map showing land classification for irrigation (see figure 2). The general soil map (figure 1) based on a reconnaissance soils survey provided the information needed for the classification for irrigation.

The general soil map is also useful in community or broad-area planning. It provides information on soil resources of large tracts that can be used for preliminary planning for irrigated agriculture, forestry, range, urban, engineering, recreation, and wildlife uses, and it shows the general location of soils that will present problems in the construction of roads or building foundations.

The general soil map of San Juan County does not replace the need for detailed soil maps for operational planning on individual farms and ranches or the planning of specific locations for houses, roads, parks, and other items of this nature. General soil maps are suitable only for general or broad area planning. They can, however, serve a very useful purpose in the planning process.

PROCEDURES

In this county, the irrigation land classes were assigned primarily on the basis of the soil data available from the general soil map (figure 1). Although maps like this one are often made by generalizing from large-scale detailed soil maps, this was possible only to a limited extent in San Juan County. Detailed soil surveys were limited to the irrigated lands and small areas of rangeland where special studies were conducted. The general soil map of this county, therefore, was prepared to a large extent on the basis of a field reconnaissance together with interpretation of airphotos, topographic maps, geological maps, and other available information.

When detailed soil surveys are completed for the entire area, some of the soil names that are used to identify the soil associations may be changed. This will not affect the usefulness of the map, however, because the names only identify the mapping units. The soil properties and qualities of the soils comprising the mapping units will not change.

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The general soil map (figure 1) was prepared by grouping geographically associated soils into 18 general soil areas. These units, referred to as "soil associations," are landscapes, or geographic areas, that have distinctive proportional patterns of soil. Each kind of soil normally occurs in a comparatively small area, so each of the units on the general soil map of San Juan County consists of two or more kinds of soil. In addition, land types and a number of less extensive soils are commonly components of the map units of this county. The kinds of soil included in each soil association are not necessarily similar. In fact, they often have contrasting characteristics that influence their use and management.

In the classification of soils for irrigation, the major soils and miscellaneous land types within each soil association were placed into one of five classes of land, depending upon their suitability for irrigated agriculture (table 5). The criteria used in the placement of soils in the irrigation land classes are those proposed at the 1967 conference organized by the Federal Water Resources Council,[3] as modified by a committee of this conference on January 12, 1968. These criteria were agreed upon by authorities from several organizations concerned with land classification and appear to have a particularly high reliability. For uniform and consistent application of these criteria and standards, the New Mexico Soils Work Group have issued guidelines and clarifications as needed and appropriate.

The classification system establishes four classes of irrigable land and one class of nonirrigable land. The limitations for use under irrigation increase from class 1 through 4. For example, class 1 has few or no limitations for use as cropland under irrigation. It is productive and well adapted to irrigation. High yields of most climatically adapted crops can be obtained on this land with good management. Class 2 land, although well suited to irrigation, has slight to moderate limitations for sustained use under irrigation. This is moderately productive land, or land that requires more than average management to obtain high yields of climatically adapted crops. Class 3 land, which has moderate to severe limitations for sustained use under irrigation, is generally not as suitable for the production of as wide a range of the climatically adapted crops as land in classes 1 and 2. This land also has a more limited productivity for many of the climatically adapted crops, or requires a very high level of management to obtain moderate to high yields. Class 4 land has a very severe limitation for sustained use under irrigation. The land included in this class is usually suited only to a relatively few of the climatically adapted crops. Some of this land may be adapted or used for the production of specialized crops under a very high level of management. Class 6 land is not suitable for irrigation.

The land in San Juan County was placed in the various irrigation land classes on the basis of soil properties and qualities that affect their suitability for continued use under irrigation. Neither the availability of irrigation water nor the cost of pumping and conveying it enters into the classification, nor was the shape, size, or location of lands with respect to other lands to be developed for irrigation considered in this classification. The detailed criteria used in the placement of land in the various irrigation land classes are listed in table 1.

The factors that affected the placement of land in the various irrigation land classes were: soil texture including gravel and stone content, effective soil depth, available water-holding capacity, salinity, permeability, erosion, surface smoothness, slope, internal soil drainage, and surface drainage. For example, the Persayo, Farb, and Travessilla soils are classified as nonirrigable because of the limited effective soil depth and very low moisture-retention capacity. In many other areas, steep slopes and rough, broken topography, together with shallow soils were the dominant factors in placing soils in a nonirrigable class. Much of the land in the Shiprock-Sheppard association (No. 4), which is dominated by deep soils on gently sloping to gently rolling landscapes, was placed in classes 2 and 3 because of unevenness of the land surface and a limited water-holding capacity.

DESCRIPTION OF THE AREA

Location and Topography

San Juan County comprises an area of 3,530,300 acres in the extreme northwestern part of New Mexico. Although the general appearance of much of the county is that of a moderately undulating plain, the area is broken by numerous small mesas, hogback ridges, steep outcrops of sedimentary rocks, and a few igneous dikes.

The northeastern part of the county is dominated by steeply sloping, rough, broken lands. It is characterized by a high-relief, stepped topography in which relatively narrow valley floors are separated from upland summits by steep canyon walls. The resistant sandstone formations in this part of the county have formed prominent structural benches, buttes, and mesas bounded by cliffs and escarpments.

[3]Proceedings Water Resources Council, Irrigation Land Classification Seminar, Salt Lake City, Utah, July 1967.

Table 1. Land classification specifications for Pacific Southwest Basin irrigation land classes[1]

Land Characteristics	Class 1	Class 2	Class 3	Class 4	Non-irrigable Class 6
Soils					
Texture (Surface 12")[2]	LVFS-CL	LS-C Peat, Muck	MS-C	MS-C	All other lands not meeting criteria for arability
Moisture Retention (AWHC-48")[3]	> 6.0"	4.5" 6.0"	3.0" 4.5"	2.5" 3.0"	
Effective Depth (inches)	> 40[4]	30- 40	20 - 30	10 - 20	
Salinity ($EC_e \times 10^3$ - equil.)	< 4	4 - 8	8 - 12	12 - 16	
Sodic Conditions[5]					
Percent area affected	< 5	5 -15	15 - 25	25 - 35	
Severity of problem[6]	Slight	Moderate	Moderate	Moderate	
Permeability (in place - in/hr)	0.2-5.0	0.05-5.0	0.05-10.0	Any	
Permissible coarse fragments (% by vol.)					
Gravel	15	35	55	70	
Cobbles	5	10	15[7]	35[7]	
Rock Outcrops (distance apart in feet)	200	100	50	30	
Soil Erosion (for all classes)	Severely eroded soils will be downgraded one class. Less severely eroded soils may be downgraded one class, depending on other conditions.				
Topography (or land development items)[8]					
Stone for Removal (cubic yards per acre)	10	25	50	70	
Slope (percent)					
Moderately to severely erodible	< 2	2 - 5	5 - 10	10 - 20	
Slightly erodible	< 4	4 - 10	10 - 20	20 - 25	
Surface Leveling or Tree Removal (amount of cover)	Light	Medium	Medium heavy	Medium heavy	
Irrigation Method	Lands unsuited to gravity irrigation where land grading would permanently reduce soil fertility below arable limits or exceed permissible costs, or field pattern too complex, may be considered for sprinkler. Land must meet other requirements for arability. Designate by "S" - example, 3-S.				
Drainage					
Soil Wetness (depth to water table during growing season with or without drainage)					
Loam or finer	> 60"	40" - 60"	20" - 40"	10" - 20"	
Sandy	> 50"	30" - 50"	20" - 30"	10" - 20"	
Surface Drainage	Good	Good	Restricted	Restricted	
Depth to Drainage Barrier (in feet)	> 7	6 - 7	5 - 6	1.5 - 5	
Air Drainage[9]	No Problem	Minor	Restricted	Restricted	

[1]Specifications are representative of conditions after land is developed for irrigation. Each individual factor represents a minimum requirement, and unless all other factors are near optimum two or more interacting deficiencies may result in land being placed in lower class or designated class 6 -- non-irrigable.

[2]Finer textures may be required than those indicated for each class in areas subject to critical hot spells or wind; coarser textures may sometimes be permissible.

[3]In areas of very warm growing season 3" may be required for class 4 and in cold areas as little as 5" may be permitted for class 1.

[4]Depth of 60" or more is required for class 1 where deep-rooted crops are important.

[5]More extensive and severe sodic problems may be tolerated in areas of wide crop adaptability.

[6]Severity of problem: Slight - ESP less than 15% or less than 25% if dominated by nonswelling clays; moderate - ESP less than 20% or less than 30% if clay minerals favorable; severe - ESP less than 30%; with certain soil minerals may range above 50% as measured by usual techniques.

[7]May range above 50% in subsoil for certain crops if surface soil is favorable.

[8]Special crop and management practices may justify exceeding the limits for stone removal or slope in class 4; irregularity of slope may necessitate downgrading of class unless deficiency is compensated for by possibility of sprinkler irrigation.

[9]Air drainage is a consideration mainly in areas adapted to fruit or to early or late vegetables.

Abbreviations:

LVFS - loamy very fine sand
LS - loamy sand
MS - medium sand
CL - clay loam
C - clay
AWHC - available water holding capacity
ESP - exchangeable sodium percentage

A relatively small mountainous area, locally known as the Chuska Mountains, is located in the southwestern part of the county. The topography of this area varies extremely, ranging from nearly level to gently sloping and undulating on the mountain top or plateau to the very steep dissected mountain slopes. The soils in this part of the county are generally developing in materials of sandstone origin.

The central and remaining parts of the county are characterized by broad, gently sloping to rolling plains and valleys with locally prominent outcrops of sandstone and shale, mesas, buttes, and hogback ridges. Many of the plains and upland areas to the east of the Chaco River have a cover of alluvial and eolian materials.

Nearly level to gently sloping valley bottoms border many of the principal drainages of the county. These occur in the entrenched valleys of the San Juan, Animas, and La Plata rivers as well as in a number of the smaller ephemeral stream systems.

The area is drained by the San Juan River which originates in Colorado and re-enters that state after making a loop through the northern part of San Juan County. In addition to the San Juan River, including the Animas, La Plata, and Los Pinos tributaries, this county contains numerous intermittent drainageways. The Chaco River, the largest of these intermittent streams, generally flows northwesterly from the southeastern part of the county to its confluence with the San Juan River just east of Shiprock. Many of the intermittent streams are bordered by highly erodible soils and barren or nearly barren shale hills. During periods of flash floods, these streams contribute considerable sediment to the drainage system.

Shiprock, in the northwest part of the county, has an elevation of 4,945 feet. From this point, the general land level increases to the north, east, and south to a maximum of slightly over 9,300 feet in the Chuska Mountains in the southwestern part of the county. Elevations of 6,800 feet to slightly more than 7,100 feet are common near the east county boundary and in the northeastern part near the Colorado-New Mexico state line.

Climate[4]

Distant high mountains shield San Juan County from much precipitation that would otherwise occur and from shallow intrusions of extremely cold air in winter. Aridity is maintained because the air from the Gulf of Mexico loses most of its moisture before it reaches northwestern New Mexico, and much of the moisture in air from over the Pacific is removed by the high western mountains over which it flows.

Average annual precipitation totals from 5 to 8 inches along the valley, generally increasing with increasing elevation to nearly 12 inches along the Colorado border and to more than 15 inches in the mountains of the southwest corner. Annual amounts may vary greatly, as shown by totals ranging from 3 inches to as much as 24 inches at Aztec Ruins National Monument area. Monthly precipitation is greatest in late summer and early fall when thunderstorms, occasionally accompanied by hail, are most active. Winter precipitation is heavier than fall or spring precipitation.

The snowfall season is November through April with annual totals averaging from 9 inches in the valley to more than 20 inches along the Colorado border and at high elevations. Snowfall in the Colorado Mountains is the primary source of summer irrigation water along the San Juan River. Temperatures rarely reach 100 degrees Fahrenheit, and only a few days a year have temperatures of zero or below. Average annual temperature is in the low fifties. The average daily range of temperature is nearly 33 degrees. so frequent freezing and thawing of the surface take place in December through March when night-time temperatures average below freezing. Extremes of temperature in the county have been 110 degrees at Fruitland and -35 degrees at Bloomfield.

The period between the last freezing or lower temperature in the spring and the first in the fall ranges from 139 days at Chaco Canyon National Monument to 170 days at the Farmington airport. The monthly pattern of temperature and precipitation in the county is illustrated in table 2 with data from Aztec Ruins National Monument. This pattern is generally applicable to other localities within the county, for which selected annual averages are listed in table 3.

Evaporation for May through October, as measured by a Class A pan, averages 49 inches at Farmington, but may be as much as 25 percent greater at higher plateau locations where there is greater wind movement.

Sunshine occurs about 70 percent of the possible number of hours. Average relative humidity is nearly 50 percent, ranging from 70 percent in early morning hours to 30 percent in the afternoons. In late spring and early summer, afternoon relative humidities are nore nearly 15 to 20 percent.

[4]This section was prepared by Frank E. Houghton, ESSA, Weather Bureau State Climatologist.

Table 2. Monthly temperatures and precipitation, Aztec Ruins National Monument, San Juan County, New Mexico, 1931 to 1960, elevation 5640 feet

Item	Jan	Feb	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Temperature (F°)												
Average daily maximum	43	49	58	68	77	86	91	88	82	70	55	45
Average daily minimum	15	20	25	32	41	48	57	56	48	37	23	17
Daily mean	29	34	41	50	59	67	74	72	65	54	39	31
Extreme maximum	66	78	80	89	95	103	104	105	96	87	80	67
Extreme minimum	-22	-27	1	10	21	31	43	41	29	13	-7	-16
Precipitation												
Average (inches)	.74	.76	.79	.60	.67	.44	.94	1.32	1.12	1.09	.49	.86
Average days 0.10 inch or more (no.)	3	3	3	2	2	1	3	4	3	3	2	3
Average snowfall (inches)	6.7	4.8	2.0	0.5	T	T	0	0	T	0.1	1.8	5.7

T - Trace, amount too small to measure.

Table 3. Annual averages of selected climatological data, San Juan County, New Mexico, for period of record through 1960

Station	Elevation	Temperatures: Mean maximum	Temperatures: Mean minimum	Temperatures: Yrs. of record	Precipitation: Mean annual	Precipitation: Yrs. of record	Last 32° F or Lower in Spring	First 32° F or Lower in Fall	Time Between Dates
	feet	° F	° F	number	inches	number	average date	average date	days
Aztec Ruins National Monument	5640	68	35	30	9.33	59	May 12	Oct. 9	150
Bloomfiled 3SE[1]	5794	68	35	51	8.46	60	May 8	Oct. 9	154
Chaco Canyon National Monument	6125	68	34	25	8.67	28	May 22	Oct. 8	139
Farmington 4NE[1]	5395	68	35	20	8.22	46	May 14	Oct. 7	146
Farmington Airport	5495	67	37	19	8.12	20	May 4	Oct. 21	170
Fruitland	5165	69	36	47	6.96	55	May 11	Oct. 7	149
Newcomb	5565	70	35	11	5.35	13	May 10	Oct. 12	155
Shiprock 1E[1]	4974	70	37	29	7.04	32	May 1	Oct. 15	167
Whiskey Creek	7450				14.97	12			

[1]Figures and letters following the station name, such as 3SE, indicate distance in miles and direction from the postoffice.

The two predominant directions of winds in the valley are from the east and west, influenced by orientation of the valley. Strong winds are most common from the west. Spring is the windiest season with an average of 10 miles per hour. Winds of 25 miles per hour or greater occur only 1 percent of the time, but they occasionally cause blowing dust when the soil is dry.

LAND USE

Although only a small percentage of the land area in San Juan County is farmed under irrigation, this agricultural enterprise contributes much to the county's economy. The present irrigation farming is largely confined to the valleys of the San Juan, Animas, and La Plata rivers. It was estimated by the State Conservation Needs Committee that approximately 49,000[5] acres of land were irrigated in 1966. Urban and industrial expansion during recent years has withdrawn some of the prime agricultural land. New lands have been brought under irrigation to replace that withdrawn for other uses; hence, there has been little or no change in total irrigated land in recent years. Alfalfa and corn are the most extensively grown crops: lesser acreages of tree fruits, small grains, beans, vegetables, and potatoes are grown, but any one of them may be the main cash crop in a particular area.

The Navajo Irrigation Project, a project authorized for construction by the Bureau of Reclamation, will provide irrigation water for

[5]New Mexico Soil and Water Conservation Needs Inventory, Statistical Report, Soil Conservation Service and other federal and state agencies, 1970.

approximately 110,000 acres of additional land in this county when the project is completed.

Ranching is the principal agricultural enterprise on the nonirrigated lands. In 1972, the county's rangeland supported about 25,000 cattle and 63,000 sheep.[6]

The use of land for wildlife and recreational purposes is also of considerable importance in San Juan County. Two national monuments, Aztec Ruins and Chaco Canyon, in the county are managed by the National Park Service. Fishing and recreational facilities are available at Navajo Reservoir, Morgan Lake, and the Animas and San Juan rivers.

DESCRIPTION OF SOILS

Eighteen soil associations are shown on figure 1. Each of these includes soils that are geographically associated and comprise recognizable landscapes. Soil associations are named for major soil series and land types that occur within them. In addition to the named soils, they often contain soils of other series. If the soil series are not known, the soils are identified at the Great Group or Subgroup level of the National System of Soil Classification. Selected soil characteristics and qualities of major soils in each soil association are summarized in table 4. A description of each of the soil associations follows:

1. Persayo-Farb association

This association occurs mainly on undulating to hilly areas in northwestern San Juan County. The soils, which are dominantly calcareous and shallow, are developing in material weathered from shale and sandstone. Exposures of shale and sandstone are common in the hilly parts. Approximately eight percent of San Juan County is included in this association.

The soils of this association are used largely for grazing of livestock and wildlife. They provide only limited grazing as they support a sparse cover of native grasses and shrubs. The principal grasses include galleta, Indian ricegrass, and blue grama. Pinyon, juniper, serviceberry, bitterbrush, saltbrush, shadscale, and snakeweed represent the more common shrubs and woody species. Due to the sparse vegetative cover and low intake rate of many of the soils, runoff is high and erosion hazard moderate to severe.

[6]New Mexico Agricultural Statistics, Vol. VI, Supplement V, New Mexico Department of Agriculture, Las Cruces, New Mexico, July 1972.

Fig. 3. Undulating to hilly soils of the Persayo Farb association (No. 1). The Farb soils shown in foreground are underlain by sandstone at shallow depths.

Soil Characteristics. Persayo soils, the most extensive in the association, are developing on upland slopes and ridges in a thin layer of calcareous material weathered from the underlying shale. They have a thin surface layer of pale yellow or light yellowish-brown granular silty clay loam. This is underlain by a light yellowish-brown or pale yellow silty clay loam subsoil that typically contains a moderate amount of partly weathered shale fragments. Concretions of calcium carbonate and crystals of calcium sulfate are also common throughout the subsoil and substratum. The depth to shale ranges from about 6 to 18 inches.

Farb soils, which are shallow over sandstone, are also relatively extensive in this mapping unit. They have a surface layer of pale brown to yellowish-brown, calcareous sandy loam. This is underlain by sandy loam or loamy fine sand that often contains a few angular fragments of sandstone gravels and cobbles. Sandstone bedrock is typically encountered at depths ranging from about 10 to 18 inches.

In addition to the two principal soils, miscellaneous land types and soils of minor extent comprise approximately 30 percent of the association. The land types include Sandstone Rock Land and Badland. These occupy the very steep slopes and breaks and are characterized by outcrops of bedrock. Soils of the Shiprock series and an associated deep loamy sand soil are also important in this unit. The Shiprock soils have a surface layer of fine sandy loam, over a thin sandy clay loam subsoil. This is underlain by loamy fine sand or sandy loam. Alluvial soils in the narrow valley bottoms and swales

contiguous to intermittent drainages also comprise a small acreage in this unit.These soils are deep and generally medium to moderately fine-textured.

Irrigation Potential. There is very little potential for the development of irrigated cropland in this unit because of steep slopes or hilly topography and and unfavorable soil properties. All soils and land types in this association are in Class 6, except those of the Shiprock and Sundown series, which are in irrigation land classes 2 and 4, respectively. They occur in small isolated tracts and are of limited extent.

2. Werlow-Fruitland-Turley association

This association, comprising an area of approximately 279,045 acres, consists of soils in the valleys of the San Juan, La Plata, Animas, Los Pinos rivers, as well as a number of smaller, intermittent drainage systems. These nearly level to gently sloping soils, which are forming in stratified alluvium of mixed origin, are dominantly deep and moderately coarse to moderately fine-textured.

The 49,000 acres of irrigated land in San Juan County is essentially all in this association. Although a wide variety of crops is grown, alfalfa and corn are the most extensive. Other crops of importance include tree fruits, small grains, vegetables, and potatoes. In addition to the irrigated land, a considerable acreage of land in this unit is occupied by urban and industrial built-up areas. Although the soils generally have favorable properties for engineering installations, wet and saline soils are included, as well as soils with moderate to high shrink-swell potential that needs to be considered in construction.

The soils not now irrigated or in urban and industrial built-up areas provide limited grazing for livestock and wildlife. Native vegetation includes galleta, Indian ricegrass, sand dropseed, alkali sacaton, salt grass, fourwing saltbrush, and snakeweed. Cottonwood trees and some salt cedar occur on the soils of the flood plains of the major rivers and streams.

Soil Characteristics. The Werlow soils, one of the more extensive soils in this association, typically occur on the nearly level to gently sloping flood plains that are contiguous to the perennial streams. These soils have a surface layer of pale brown or grayish-brown calcareous loam over stratified subsurface layers of loam, very fine sandy loam, silt loam, or fine sandy loam to a depth of 60 inches or more. Thin strata of clay loam or loamy sand may also occur occasionally in the substratum. These soils have variable drainage characteristics with watertables that usually fluctuate between depths of about two and seven feet.

Fruitland soils usually occur on the gently to strongly sloping alluvial fans and valley-filling slopes. They typically have a yellowish-brown or brown, calcareous sandy loam surface layer, about five to eight inches thick. This is underlain to a depth of about three to four feet by a yellowish-brown or pale brown sandy loam. The substratum is a light yellowish-brown to pale brown sandy loam, fine sandy loam, loamy sand, or sand to a depth of 60 inches or more.

Turley soils, which are also an important compoent of this association, are forming in moderately fine-textured, calcareous alluvium or gently sloping fans that lie between the mesa escarpments and flood plains. The surface layer is a grayish-brown clay loam about five inches thick. The subsoil is a yellowish-brown or light brown clay loam about 35 inches thick. The substratum, which is similar in color, consists of weakly stratified clay loams, silty clay loams, or loams. The soil ranges in reaction from noncalcareous or weakly calcareous to moderately calcareous.

The Azfield soils, although not included in the association name, are also of moderate extent in

Fig. 4. Werlow-Fruitland-Turley association (No. 2). These deep, nearly level to gently sloping soils shown in foreground are well suited for use as cropland under irrigation. Rock Land is shown on the steep breaks and escarpments in the background.

this general soil area. These soils are forming in mixed, medium-textured, calcareous alluvium on gently sloping alluvial fans or plains and terraces. They typically have a brown or grayish-brown calcareous loam surface layer. The subsurface layers to a depth of about three feet consist of brown, pale brown, or light yellowish-brown loams. The substratum to a depth of five feet or more is usually a pale brown very fine sandy loam or fine sandy loam. Although colors given for Azfield soils are typical, there are also some light reddish-brown or reddish-brown soils in this series.

Other soils of importance in this unit include a number of unclassified soils, as well as those of the Aton, Bisti, Christianburg-like, Sundown, and Billings series. The Aton soils are forming in very gravelly, calcareous alluvium on nearly level to strongly sloping river terraces. These soils, which have pale brown to brown loam, clay loam, or gravelly loam surface layers and subsoils, are usually underlain within a depth of 20 inches by very gravelly sand. The Bisti soils occupy nearly level to very gently sloping flood plains or low river terraces. They consist of weakly stratified clay loams, silty clay loams or silt loams to a depth of 60 inches or more. They are affected by wetness and varying amount of salt accumulations. Water tables fluctuate between two and seven feet. Christianburg-like soils, which are deep and fine-textured or clayey, are typically strongly calcareous and usually contain some gypsum and soluble salts. They occur on nearly level fans and flood plains adjacent to ephemeral streams. Sundown soils commonly occupy gently to strongly sloping alluvial fans below escarpments or breaks. These deep, light brownish-gray soils have profiles of loamy sand or loamy fine sand. The Billings soils typically occur in swales and on flood plains of intermittent drainages. They are light gray or light brownish-gray, deep, and moderately fine-textured. Saline and wet phases of Werlow and Turley soils also occur to a limited extent. The unclassified soils include brown to light reddish-brown clay loams, silty clay loams and silt loams. These deep soils commonly occur on nearly level to gently sloping alluvial fans and flood plains of intermittent drainages in those units of this association located in the western part of the county.

Miscellaneous land types such as Alluvial Land, Gullied Land, Riverwash, and Marshland comprise about 10 percent of this association.

Irrigation Potential. The major soils in this association are well suited for use as cropland under irrigation. Approximately 30 percent of the land in this unit is in land class 1; 36 percent in class 2; 14 percent in class 3; and 10 percent in class 4. On the basis of soils there is considerable opportunity for expansion of irrigated land in this association. These soils are, however, widely distributed throughout the county and often occur in relatively small tracts. The shape, size, and location of many of these potentially irrigable soils areas may, therefore, preclude their use for irrigation because of high development costs.

3. Doak-Shiprock association

The soils of this association occupy the gently sloping tops of elevated benches or mesas in the northern and southeastern parts of the county. The soils have formed mainly in thick alluvial deposits on ancient stream terraces or alluvial fans. Past geologic erosion has worn away much of the original landscape, so that the soils of this unit now occur on elevated mesas that are as much as 100 to 300 feet above the stream channels. This association comprises about five percent of the land area in San Juan County.

It is used principally for grazing of livestock. Fair yields of forage are obtained under good management. Native vegetation includes galleta, Indian ricegrass, blue grama, sagebrush, snakeweed, and a number of annuals.

Soil Characteristics. The Doak soils, the most extensive in the association, occur on nearly level or in slight depressional areas. These soils have a thin surface layer of light brown or brown, noncalcareous loam. Their subsoil is a brown clay loam that usually contains a few streaks and soft masses of lime in the lower part. This is underlain by a light brown sandy clay loam or clay loam with visible calcium carbonate occurring in finely divided forms and as thin seams and streaks.

The Shiprock soils occur on the gentle slopes just above those of the Doak series. They have a thin surface layer of light brown or light reddish-brown, noncalcareous fine sandy loam. Their subsoil is a brown to reddish-brown noncalcareous, heavy fine sandy loam. This horizon typically extends to a depth of 15 to 20 inches. The substratum is a reddish-brown to reddish-yellow calcareous sandy loam or loamy fine sand. A few fine filaments and small soft masses of lime are usually present in the upper part of this horizon.

Grandview soils, which are characterized by a moderate to strong lime zone at depths of 12 to 18 inches, are also moderately extensive in this association. They are forming in medium to moderately fine-textured eolian and alluvial sediments

Fig. 5. The deep and gently sloping Doak soils in foreground are well suited for irrigation. The steep Rock Land shown in background is in the Persayo-Farb association (No. 1).

on gently to strongly sloping and undulating mesa tops. The surface layer is brown or light brown, calcareous loam about five inches thick. The subsoil to a depth of about 36 to 40 inches consists of a light brown or yellowish-red loam or light clay loam that typically contains many pinkish-white medium to large masses of lime. The soil peds are often lime coated. The substratum to a depth of five feet or more is a light brown to light yellowish-brown very fine sandy loam or light loam.

Also in this association are small areas of unclassified soils, miscellaneous land types and soils of the Aton and Persayo series. The Aton soils occupy nearly level to gently sloping high river terraces and mesa tops that lie several hundred feet above the present flood plains. These soils have brown to pale brown loam, clay loam or gravelly loam surface layers over a white, weakly to moderately cemented very gravelly loam or very gravelly sandy loam with a high lime content at depths of 10 to 20 inches. The Persayo soils have light-colored, calcareous silt loam or silty clay loam surface layers over shale that occurs at a depth of 6 to 20 inches. Hilly Gravelly Land and Rough Broken Land are the principal miscellaneous land types. These include the steep mesa side slopes, breaks, and ridges.

Irrigation Potential. The major soils in this association are deep, low in salts, and, if properly managed, not highly erodible. These soil properties, together with their moderate to high water-holding capacity, make them well suited to irrigation. Approximately 80 percent of the land in this association is in classes 2 and 3, hence there is opportunity for expansion of irrigation when tracts are of sufficient size and so located that irrigation water can be made available feasibly.

4. Shiprock-Sheppard association

This association comprises the gently sloping to gently rolling upland areas south and east of San Juan and Chaco rivers, respectively. The soils, which are dominantly sandy and deep, are developing in sandy alluvial and eolian deposits. These deposits, in turn, are underlain by sedimentary rocks. Although some of the underlying shales have relatively low permeabilities, the alluvium and eolian materials are generally thick enough to permit adequate subsurface drainage. With the exception of the area immediately to the west of Gallegos Canyon, the ground surface generally slopes to the west and southwest. This unit includes about 352,070 acres, or 10 percent of San Juan County.

The soils of this association, which at present are used principally for the grazing of livestock, generally support a moderately dense cover of vegetation. Under good management moderate yields of forage are obtained. Native vegetation includes galleta, blue grama, Indian ricegrass, sand dropseed, poverty three-awns, snakeweed, big sagebrush, common winterfat, and long-leaf ephedra.

Soil Characteristics. The Shiprock soils usually occur on the nearly level to gently sloping part of the area occupied by the soils of this association. They have a thin surface layer of light brown or light reddish-brown noncalcareous fine sandy loam. Their subsoil is a brown to reddish-brown noncalcareous heavy fine sandy loam. This horizon typically extends to a depth of 15 to 20 inches. The substratum is a reddish-brown to reddish-yellow calcareous sandy loam or loamy fine sand. A few fine streaks and small soft masses of lime are usually present in the upper part of the substratum.

The Sheppard soils, in this association, occupy the gently rolling or dunelike areas. The ridges and dunes are oriented in the direction of the prevailing winds, or in a southwest to northeast direction. They have surface layers of loose, weakly calcareous pale brown or light reddish-brown loamy fine sand. This is underlain by a moderately calcareous sand, fine sand, or loamy sand to a depth of five feet or more.

Nageesi soils usually occur on the gentle slopes in close association with the Shiprock soils. Nageesi soils are characterized by their calcareous surface

soils and pinkish-white lime zones at shallow to moderate depths. They usually have moderately thick surface layers of light brown or reddish-yellow sandy loam. The lower part is typically more limy than the upper part. This layer grades through a pale brown sandy loam to very limy pinkish-white loam at depths ranging from 10 to 20 inches.

Kinnear soils, which are also moderately extensive in this association, commonly occur in small depressional areas as well as on the adjacent side slopes. They are usually gently sloping and undulating, but may range from nearly level to strongly sloping. The surface layer is typically a brown, slightly calcareous, fine sandy loam or very fine sandy loam about eight inches thick. This is underlain to a depth of 30 to 48 inches by reddish-yellow sandy clay loam, loam, or very fine sandy loam that contains soft masses and threads of segregated lime. The substratum to a depth of five or more feet is typically a loamy sand, but may range in texture from a sand to a fine sandy loam or very fine sandy loam.

Also in this association are soils identified as Typic Camborthids, shallow and moderately deep soils underlain by interbedded sandstone and shale, and small areas of miscellaneous land types. The Typic Camborthids resemble the Shiprock soils, but have coarser textured substrata. They are typically underlain by sand at a depth ranging from about 20 to 24 inches. The shallow soils, which have brown or light brown fine sandy loam or light loam surface layers are underlain by shale or shale interbedded with sandstone at depths of 6 to 20 inches. The moderately deep soils are similar except that the interbedded shale and sandstone occurs below a depth of 20 inches and usually within a depth of 60 inches. The miscellaneous land types include small areas dominated by outcrops of shale and sandstone, Gullied Land and Alluvial Land.

Irrigation Potential. The association comprises the major portion of the land to be irrigated under the Navajo Irrigation Project. Although these soils do have some limitations, their properties in general make them suitable for use as cropland under irrigation. Shiprock soils and soils with similar characteristics comprise about 35 percent of the land in this association. These soils, which are in class 2, have moderate water-holding capacities and permeabilities. The Kinnear soils are also in class 2 when gently sloping and in class 3 when occurring on undulating and strongly sloping landscapes. The Nageesi soils, which comprise about 10 percent of this association, were placed in class 3, due primarily to their limited depth to massive, strong lime zones and moderate water-holding capacities. Sheppard soils and closely related sandy soils which comprise approximately 20 percent of this association were placed in land class 3. These soils have a high rate of water intake, rapid permeability, and low water-holding capacities. Of these, the limiting factor is the water-holding capacity. Wind erosion is a moderate hazard, and careful management will be needed to minimize damage by wind.

Fig. 6. Gently sloping and undulating landscapes are common in the Shiprock-Sheppard association. The gently sloping Shiprock soils are shown in the foreground. Sheppard soils occupy the gently rolling ridges.

5. Hilly Gravelly Land association

Included in this association are the steep side slopes or escarpments of old river terraces and mesas. Although there are occasional exposures of sandstone and shale, this unit is characterized by a thin veneer of gravelly alluvium on the surface. In addition to the gravelly alluvium, shallow soils and colluvial material at the base of the mesa escarpments or slopes are common. This unit, which occurs dominantly along the Animas, La Plata, and San Juan rivers, generally forms the divide between the river valley bottoms and the uplands. It is not extensive, as it comprises an area of only about 43,600 acres.

The principal use of the soils in this unit is for grazing of livestock. They support a sparse cover of native grasses, including galleta, blue grama, Indian ricegrass, sand dropseed, three-awn, ring muhly, and western wheat. Sagebrush, snakeweed, rabbit brush,

Fig. 7. Moderately steep to steep and hilly landscapes are common in the Hilly Gravelly Land association (No. 5).

and juniper are some of the more common shrubs. Although these soils support only a sparse cover of vegetation, they are not particularly susceptible to serious damage by either wind or water erosion. The numerous gravels and cobbles in the surface layer help to stabilize the soil material. They are also often underlain by sand and gravel strata, which vary greatly with the thickness and percentage of gravel and sand. The thicker deposits offer a potential source for sand and gravel.

Soil Characteristics. Hilly Gravelly Land, a miscellaneous land type, is the principal component of this unit. It typically has a thin surface layer of gravelly loam or cobbly loam. The subsoils are quite variable, ranging from loams that contain very little gravel and cobble, to those that are very gravelly and cobbly. These soils, or soil materials, are usually shallow to gravel and cobble, sandstone, or shale.

Also occurring in this association are small areas of Doak and Grandview soils. The gently sloping Doak soils are forming in mixed, moderately fine-textured, calcareous, alluvial and eolian sediments. The surface layer is a brown or light brown loam about four to six inches thick. The subsoil is a brown to reddish-brown clay loam or silty clay loam about 35 inches thick. This is underlain by a light brown sandy clay or clay loam. The soil becomes calcareous below 20 inches, with visible lime occurring as small soft masses and thin seams or streaks.

The Grandview soils are also forming in calcareous alluvial and eolian sediments, but differ from the Doak soils in that they have a moderate to strong lime zone at depths of 12 to 18 inches. These soils have a surface layer of brown to light brown, calcareous loam over a light brown or yellowish-red loam or light clay loam that typically contains many pinkish-white medium to large masses of lime. This is underlain at a depth of about 36 to 40 inches by a light brown to light yellowish-brown very fine sandy loam or light loam.

The remaining parts of this association consist of a number of other miscellaneous land types and small areas or pockets of unclassified soils. These soils are usually shallow and moderately coarse to medium textured. Small areas of deep sandy and loamy soils, however, occur in valley bottoms and at the base of steep escarpments and breaks. Rock Land and Badland, consisting of outcrops of sandstone and shale respectively, are the more extensive land types.

Irrigation Potential. Hilly Gravelly Land is generally not suitable for use as irrigated cropland because of the steep slopes and unfavorable soil properties. The 10 percent of class 2 land in this association is widely distributed as small areas on mesa tops and alluvial side slopes. Due to problems inherent in transporting irrigation water to these small isolated tracts of class 2 land, there is little, if any, opportunity for expansion of irrigated land in the areas occupied by this association.

6. Badland-Rock Land association

This association, the largest in San Juan County, includes an area of about 520,255 acres, or 15 percent of the county. Surface relief ranges from nearly level in the narrow alluvial valley bottoms, through rolling hills, to very steep slopes on escarpments and breaks. It is widely dispersed throughout the county where exposures of shale and sandstone are prevalent. The barren or nearly barren outcrops of shale and sandstone are a characteristic feature of this association.

The land types and soils of this association are used as rangeland. The Badland part of this association supports little vegetation and is of very limited value, even as range. The remaining parts of the association support a sparse cover of native grass, forbs, and brush suitable for grazing by livestock and wildlife. The escarpments, steep slopes, and rock outcrops tend to restrict the movement of livestock in many parts of this unit.

Soil Characteristics. Badland, the most extensive of the miscellaneous land types comprising this unit, consists of barren or nearly barren outcrops of shale. It is forming primarily in soft shale that is in various stages of weathering. The landscape is one of rolling hills, separated by very narrow valleys or

numerous intermittent drainage channels. Due to the low intake rates and very slow permeability, a large amount of water runs off after a normal rain and flash floods follow heavy rains. Seepage and the movement of moisture through the shale materials often cause soluble salts to concentrate in low places and sidehills where seepage water emerges.

Rockland includes escarpments, breaks, and steeply sloping sides of mesas. It is a complex of shallow-soils, sandstone outcrops, and exposures of other types of sedimentary rocks. The sandstone outcrops may appear as vertical exposures or as ledges. A thin mantle of rocky or stony soil material commonly occurs between the ledges or outcrops of bedrock.

Alluvial land includes the moderately deep and deep alluvial soils in the narrow valleys and drainageways within this association. These soils, which are usually stratified and vary widely in texture, commonly receive runoff from adjacent areas.

Also in this association are Farb soils which are shallow over sandstone, the Persayo soils which are shallow over shale, and the deep sandy loam soils of the Shiprock series.

Irrigation Potential. Due to shallow soils, steep slopes, and other unfavorable soil properties, the areas included in this association essentially have no potential for development of irrigated land.

Fig. 8. Badland is a major component of soil association number 6. It consists of a complex of very shallow soils and outcrops of shale. This land type supports only a very sparse cover of vegetation. The shale outcrops are usually barren.

7. Turley-Badland association

This association includes extensive areas in the southeastern part of San Juan County. It consists of gently sloping, broad, moderately incised valleys, and associated sloping and gently rolling uplands. Deep soils are dominant in the valley bottoms and on the valley slopes, while shallow soils with some outcrops of shale and sandstone are more common in the upland areas. The soils are developing residually in materials of sandstone and shale origin, or in alluvium of similar origin. This association includes about 171,485 acres, or five percent of the land area in San Juan County.

This association is used mainly as native range. The Badland and Rockland areas of this association are barren or support only a sparse cover of vegetation. The remainder of the areas support a fair cover of native grasses and shrubs, including galleta, blue grama, alkali sacaton, western wheatgrass, Indian ricegrass, sagebrush, and broom snakeweed. Thin stands of pinyon and juniper also occur on the shallow soil and the steeply sloping areas.

Soil Characteristics. Turley soils, the most extensive in the association, occur dominantly on the gently sloping and undulating valley-filling slopes. They have a moderately thick surface layer of grayish-brown, calcareous, clay loam. This is underlain to a depth of five feet or more by a light olive brown or pale brown calcareous clay loam.

The Farb soils, which occur on the sloping and gently rolling uplands, are typically shallow over sandstone. They have a surface layer of pale brown calcareous sandy loam. Their subsoil is a very pale brown calcareous loamy sand or sandy loam. This is underlain by sandstone at depths ranging from 10 to 20 inches.

Areas identified as Badland comprise about 20 percent of this association. It is dominantly in the fringe areas just above the valley-filling slope surfaces, but does occur to a lesser extent throughout the association. It is forming mostly in soft shale that is in various stages of weathering. The landscape is one of rolling hills and very steep escarpments. It consists generally of barren or nearly barren outcrops of shale.

Azfield soils are also an important component of this association. These soils are forming in mixed, medium-textured, calcareous alluvium on gently sloping alluvial fans and flood plains. The surface layer is a brown or light olive brown calcareous loam. The subsurface layers to a depth of 60 inches or more consist of weakly stratified, brown or olive brown loams, light clay loams, and very fine sandy loams.

Fig. 9. The deep, gently sloping Turley soils of the Turley-Badland association (No. 7) are shown in foreground. Small areas dominated by shale and sandstone outcrops occur in upper right background.

The remaining 15 percent of this association consists of unclassified deep sandy and loamy soils, shallow Persayo soils and other miscellaneous land land types, principally Rock Land.

Irrigation Potential. The Turley and Azfield soils and associated deep sandy and loamy soils have properties suitable for use as cropland under irrigation. Approximately 45 percent of this association is in irrigation land class 2; 3 percent in class 4; and the remainder in class 6. The size of tracts that can be developed for irrigation, however, will be limited due to the relatively high percentage of interspersed nonirrigable land.

8. Rock Land-Billings association

This association is rough and broken. It is characterized by steep canyon walls, buttes, escarpments, outcrops of shale and sandstone, and relatively narrow valley floors. With the exception of alluvial soils in the valley bottoms, the soils generally are shallow. This unit, which is located in the southern part of the county, includes about 113,410 acres, or three percent of the land area in the county.

Lands in this association are used for the grazing of livestock and wildlife. The vegetative cover ranges from barren to nearly barren on shale and sandstone outcrops to fairly dense stands on more favorable soil sites. Galleta, alkali sacaton, Indian ricegrass, and blue grama represent the more common grasses. Shrubs and woody species include pinyon, juniper, greasewood, shadscale, and snakeweed.

Soil Characteristics. Rock Land, a miscellaneous land type, and shallow soils make up the major part of the association. Rock Land is usually very steep exposures of sedimentary rocks on escarpments, buttes, and ledges. A thin mantle of soil material of variable texture commonly occurs between the ledges or outcrops of bedrock.

Billings soils are mainly on the nearly level to gently sloping valley bottoms and adjacent valley-filling slopes. They are calcareous throughout, deep, and moderately fine-textured. These soils have a thin surface layer of light gray or light brownish-gray silty clay loam. The underlying material to a depth of five or more feet is dominantly a light brownish-gray silty clay loam or clay loam. There are toxic concentrations of soluble salts in many of the Billings soils in this unit. They are also subject to piping and severe gully erosion.

Other soils of importance in this association include those of the Christianburg, Farb, and Sundown series. Christianburg soils occur in the valley bottoms in close association with those of the Billings series. They are deep, calcareous, and fine-textured. The deep Sundown soils typically have light-brown loamy sand surface layers and subsoils. This is underlain by loamy sand or sand. Farb soils have a surface layer of pale brown to yellowish-brown calcareous sandy loam. This is underlain by sandy loam or loamy fine sand that often contains a few angular fragments of sandstone gravels and cobbles. Sandstone bedrock is typically encountered at depths ranging from about 10 to 18 inches.

Irrigation Potential. This association offers very little potential for the development of irrigated land due to unfavorable soil and topographic conditions.

Although the deep soils in the valley bottoms have properties suitable for irrigation, their shape, size, and location will tend to limit the development for this purpose. In addition, salinity, susceptibility to overflow, and gully erosion are other limiting factors. About 30 percent of this association is in land classes 3 and 4, and the remaining 70 percent is in class 6.

9. Camborthid-Farb association

Soils of this association occur on gently sloping and undulating upland plains in western and southern parts of the county. In general, they are developing residually from materials of sandstone origin.

Characterized by sandy surface layers, these soils are moderately susceptible to wind erosion when the vegetative cover becomes depleted or is removed. This unit includes about 114,480 acres, or three percent of the land area in the county.

Soils of this association are best used as rangeland. They support a fair cover of grasses and shrubs under good management. Native vegetation includes galleta, blue grama, Indian ricegrass, sand dropseed, poverty three-awn, rabbit brush, and snakeweed.

Soil Characteristics. Typic Camborthids, the most extensive in the association, are underlain by sandstone or interbedded sandstone and shale at moderate depths. These soils have a thin surface layer of light brown or brown calcareous fine sandy loam. The subsoil, which is of similar color and texture, contains some segregated lime in the lower part in the form of thin white streaks and small soft masses. Sandstone bedrock is usually encountered at depths ranging from about 20 to 35 inches.

Farb soils that are shallow to sandstone are also relatively extensive in this mapping unit. They have a thin surface layer of light brown calcareous fine sandy loam. This is underlain by fine sandy loam or very fine sandy loam that usually contains a few small angular fragments of sandstone. Sandstone bedrock typically underlies these soils at depths ranging from 10 to 20 inches.

In addition to the two principal soils, miscellaneous land types and soils of minor extent comprise about 20 percent of the association. Rock Land, consisting essentially of exposures of sandstone, is the principal land type. A shallow soil over gravel and a deep sandy soil comprise minor acreages in this association. The deep sandy soils have light brown, weakly calcareous, fine sandy loam or very fine sandy loam surface layers. The subsoil is a light brown or pale brown fine sandy loam about 30 inches thick. This is underlain to depth of 60 inches or more by fine sandy loams and loamy fine sands. A few fine threads and small soft masses of lime typically occur in the lower part of the subsoil.

Irrigation Potential. This association, although containing a relatively high percentage (about 65 percent) of irrigable land, is dominated by soils poorly suited to irrigation. This is reflected in the irrigation land classification, as only 10 percent is in land class 2, while 55 percent is class 4. The remaining 35 percent is in land class 6. Soils in this unit are generally underlain by sandstone bedrock, so drainage problems could develop under irrigation. More detailed soil investigations are recommended prior to considering these soils for irrigation.

10. Persayo-Billings association

This association occurs mainly west of the Chaco River in the northwestern part of the county. It is characterized by undulating to rolling and moderately dissected plains with locally prominent uplands comprising hogbacks, mesas, domes, and volcanic outcrops. The soils, which are light colored, calcareous, and highly erodible are forming in material weathered from yellow or gray cretaceous clay shales. Approximately 324,135 acres or nine percent of the land area of the county is included in this association.

Although the soils of this association generally support only a sparse cover of vegetation, they are best suited to use as rangeland. Shadscale and galleta grass are the dominant vegetation. Other grasses and shrubs of importance include Indian ricegrass, alkali sacaton, globemallow, snakeweed, and various annuals.

Soil Characteristics. Persayo soils, the most extensive in the association, have a thin surface layer of light gray to pale yellow granular silty clay loam. They have a pale yellow or light yellowish-brown, calcareous silty clay loam subsoil that usually contains moderate amounts of partly weathered shale fragments. A few streaks and small soft masses of lime and crystals of calcium sulfate are also common throughout this horizon. The depth to shale ranges from about 6 to 18 inches.

The Billings soils typically occur in swales and on flood plains of intermittent drainages. They are calcareous throughout, deep, and moderately fine-textured. These soils have a thin surface layer of light gray or light brownish-gray silty clay loam.

Fig. 10. General view of the undulating and gently rolling topography that is characteristic of the Persayo-Billings association (No. 10). The shallow, light-colored Persayo supports a sparse cover of vegetation.

This is underlain by weakly stratified silty clay loams, silt loams, and clay loams to a depth of five feet or more.

Included in the association are small acreages of Christianburg and Ravola soils. The Christianburg soils are deep and fine-textured; the Ravola soils, deep and medium-textured. Badland, Rock Land, and Gullied Land also comprise minor acreages in this association.

Irrigation Potential. The Billings and associated deep alluvial soils have properties suitable for use as cropland under irrigation. Approximately seven percent of this association is in irrigation land class 2; 25 percent in class 3; and three percent in class 4. Even though over 113,000 acres of land have been classified as suitable for irrigation, the potential for expansion of irrigation in this unit is very limited. These irrigable lands occupy swales and low-lying positions in association with the shallow soils of the Persayo series. In addition to the problems inherent in the transportation of irrigation water to small isolated tracts, the soils included in the irrigable land classes are susceptible to accumulation of salts and development of unfavorable drainage conditions.

11. Persayo-Rock Land association

This association comprises an area of approximately 200,690 acres in the southwestern part of San Juan County. A gently sloping to undulating and rolling type of topography prevails throughout the areas included in this unit. A characteristic feature of the landscape, however, is the low tilted ridges and ledges with outcrops of bedrock. Although differences in local relief are not great, the faces or exposures of sandstone and interbedded shale outcrops are nearly vertical or very steep.

The soils of this association, which support only a sparse cover of vegetation, are best used as rangeland. Native vegetation includes galleta, Indian ricegrass, alkali sacaton, shadscale, globemallow, snakeweed, and various annuals.

Soil Characteristics. Persayo soils, the most extensive, are typically underlain by shale beds at a depth of less than 20 inches. They have a thin surface layer of light gray to pale yellow granular silt loam or silty clay loam. This is underlain by a light yellowish-brown, calcareous silty clay loam subsoil that usually contains moderate amounts of partly weathered shale fragments. A few fine streaks and soft masses of lime and crystals of gypsum are also common in the subsoil immediately above the underlying shale.

Typic Camborthids, which are underlain by sandstone at moderate depths, are also relatively extensive in this association. These soils have a thin surface layer of light brown or brown calcareous fine sandy loam. The subsoil, which is of similar color and texture, typically has a few fine streaks and small soft masses of lime in the lower part. These soils typically are underlain by sandstone bedrock at depths ranging from 20 to 40 inches.

Rock Land, a miscellaneous land type, is also an extensive component of this association. It is a complex of very shallow soils and outcrops of sandstone and other types of sedimentary rocks. These outcrops often occur as relatively low, very steep or nearly vertical exposures or ledges.

Also in this association are Billings and Woodrow-like soils, which are moderately fine-textured, and Christianburg-like soils, which are fine-textured. In addition to these deep soils, shallow soils over gravels and cobbles occur to a limited extent. They are mainly on crests and side slopes of piedmont fans.

Irrigation Potential. There is very little potential for development of irrigated land in the areas included in this association. Although soils of the Billings, Christianburg-like, and Woodrow-like series are irrigable, they are of limited extent in this unit, and often occur in small isolated tracts which would make irrigation extremely difficult.

12. Chipeta-Sheppard-Shiprock association

This association includes an area of about 151,815 acres in the south-central part of the county. It consists dominantly of erosional slopes intermediate between the uplands on the east and the flood plain of the Chaco River to the west. Locally there are small, nearly level to gently sloping, flood plains contiguous to the intermittent drainages. In addition, gently sloping and undulating valley slopes and intermediate uplands with a mantle of eolian or alluvial sandy materials of varying thickness comprise a significant part of this association. Although geographically associated, the soils in the unit have contrasting characteristics and properties, ranging from deep sandy soils forming in eolian sands to those shallow over shale.

The soils of this association are used as rangeland. Galleta, alkali sacaton, and shadscale represent the dominant native vegetation on the Chipeta soils. However, associated with the Chipeta soils are numerous barren areas of shale and sandstone exposures, slickspots, and thin eroded soils. The Sheppard and Shiprock soils in this association support a fair cover of native grasses and shrubs unless

Fig. 11. General view of the Chipeta-Sheppard-Shiprock association (No. 12). The deep, sandy, and rolling soils of the Sheppard series are shown in the foreground. The shallow and clayey soils of the Chipeta series are in the upper left background.

severely eroded. The more common grasses are galleta, sand dropseed, sideoats grama, Indian ricegrass, and blue grama.

Soil Characteristics. Chipeta soils, the most extensive, are shallow and fine-textured. They are developing on rolling uplands, ridges, and steeply sloping parts of valley-side slopes. They have thin surface layers of pale brown to light yellowish-brown calcareous clay. This layer grades through a light yellowish-brown or gray clay to shale at depths of 10 to 20 inches. Numerous exposures of shale and coal are associated with these soils.

Sheppard soils, which are deep and sandy, are developing in sandy eolian materials. They have surface layers of loose, weakly calcareous pale brown or light reddish brown, loamy sand which are underlain by loamy sand or sand to a depth of five feet or more. Wind eroded and duny areas are common.

Shiprock soils, in this association, usually occur in the level or nearly level and more stable areas. They have thin light brown or light reddish-brown noncalcareous surface layers and reddish-brown heavy fine sandy loam subsoils. The substratum is a reddish-brown to reddish-yellow calcareous sandy loam or loamy fine sand. A few fine streaks and small soft masses of lime are usually present in the upper part of the substratum.

Barren or nearly barren exposures of sedimentary rocks and alkali-affected soils comprise from 5 to 10 percent of this association.

Irrigation Potential. The potential for the development of irrigated land in this association is very limited. The Sheppard and Shiprock soils, which are suitable for irrigation, commonly occur in relatively small tracts surrounded by large areas of nonirrigable land. In addition, the Sheppard soils, because of their low water-holding capacity and high susceptibility to wind erosion, have severe limitations for use as cropland under irrigation.

13. Rock Land-Torriorthent association

This association comprises an area of about 118,485 acres in the northwestern part of San Juan County. It is a very dissected area with extremes in relief. It consists generally of a series of angular tilted ledges of sandstone rock, and plateaus bounded by deeply incised valleys and drainages which expose sandstone and other interbedded sedimentary rocks. The area is dominated by sandstone rockland and shallow soils developing on sandstone and shale. Deep alluvial soils occur in the narrow valleys and drainage ways.

Soils of this association are used as rangeland and for recreational areas. The more common native vegetation includes juniper, pinyon, galleta, blue grama, Indian ricegrass, snakeweed, yucca, and shadscale.

Soil Characteristics. Rock Land, a miscellaneous land type, is extensive in this association. It consists generally of a complex of shallow soils and outcrops of sandstone and other types of sedimentary rocks. The sandstone rock outcrops may occur as angular tilted ledges or on very steep canyon walls and escarpments. A thin mantle of soil material often occurs between the outcrops of bedrock.

Lithic Torriorthents, which are forming dominantly in materials weathered residually from sandstone or interbedded sandstone and shale, are also relatively extensive in this association. These soils have a thin surface layer of light reddish-brown calcareous loam. This is underlain by reddish-brown calcareous loam or clay loam. Sandstone bedrock typically underlies these soils at depths ranging from 10 to 20 inches.

Also of importance in this unit are the deep alluvial soils in the narrow valley bottoms and on the adjacent valley slopes. These soils, which are dominantly medium-textured, may range in texture from moderately coarse to moderately fine.

A few exposures or outcrops of shale and shallow soils developing over shale are also in this unit.

Irrigation Potential. There is very little potential for development of irrigated lands in the areas com-

prising this association due to the prevalence of rough, broken, and steep topography, rock outcrops, and shallow soils. The only irrigable soils are the deep soils in the valley bottoms, which have been placed in class 4. The location, shape, and small extent of these soils will tend to limit their use as irrigated cropland.

14. Travessilla-Rock Land association

This association comprises relatively extensive areas in the northeastern part of San Juan County. It includes an area of about 330,170 acres, or nine percent of the land area in the county. This unit is characterized by rough broken topography. The relatively narrow valley floors and upland summits are separated by steep canyon walls and escarpments. The fans and valley floors below the canyon walls or escarpments are gently to strongly sloping. The mesa tops or upland areas, which are usually comparatively small, are gently sloping to rolling. Thin deposits of silty eolian materials or gravelly alluvium cover a considerable part of the upland area. Outcrops of sandstone bedrock are also a common feature of these upland areas.

The soils of this association are used principally for grazing by livestock and wildlife. Although the density of vegetation is somewhat restricted due to rock outcrops, thin soils, and steep slopes, this unit does support a wide variety of grasses and shrubs. Blue grama, galleta, sideoats grama, Indian ricegrass, little bluestem, poverty three-awn, and sand dropseed are the principal grasses. The more common shrubs and woody species include pinyon, juniper, big sage, bitterbrush, serviceberry, snakeweed, rabbit brush, and cactus. The use of land in this unit for recreational purposes is also of considerable importance. In addition to fishing available in Navajo Reservoir, this association provides a good habitat for many species of wildlife.

Soil Characteristics. Travessilla soils, the most extensive, are shallow, light-colored, gently to strongly sloping soils developing on sandstone mesas and breaks. They have a thin surface layer of light brownish-gray to pale brown sandy loam. The subsoil consists of pale brown calcareous fine sandy loam. This is underlain by sandstone bedrock at depths ranging from 8 to 20 inches. Small angular fragments of sandstone are common in the subsoil above the bedrock.

Rock Land, a miscellaneous land type, is also an extensive component of this association. It is a complex of shallow soils and outcrops of sandstone and other types of sedimentary rocks. The sandstone outcrops commonly occur as vertical exposures or ledges. A thin mantle of rocky or stony soil material generally occurs between the ledges or outcrops of bedrock.

Exposures of shale may also occur on the lower parts of the breaks and escarpments. Associated with these outcrops of shale are shallow Ustic Torriorthents which are forming in materials weathered from shale. They occupy the gently sloping to rolling areas at the base of escarpments and cliffs. They have thin surface layers of grayish-brown calcareous clay loam or silty clay loam. This grades through soil material of similar color and texture to the underlying shale which usually occurs at depths of 10 to 20 inches.

Other soils of lesser extent in this association include the deep alluvial soils in the valley bottoms, shallow to moderately deep gravelly soils developing in alluvium on the upland ridges and soils of the Del Rio series. The Del Rio soils, which are deep, have thin surface layers of reddish-brown loam and blocky silty clay loam subsoils. The deep alluvial soils in the narrow bottoms are usually grayish-brown or brown and range in texture from medium to fine. The gravelly soils occur on the upland ridges and slopes in the northern parts of this unit near the Colorado-New Mexico state line. They have dark-colored gravelly or cobbly loam surface soils and blocky clay subsoils.

Irrigation Potential. Due to the preponderance of shallow soils and steep, rough broken landscapes, there is little, if any, opportunity for the development of irrigated land in this association. The Del Rio soils, which account for about six percent of the association, have been placed in classes 2 and 3, primarily due to slope and unevenness of the land surface. They occur as small isolated tracts on mesa tops and ridges. The deep alluvial soils also occur as small areas. However, in contrast to the Del Rio soils they occupy flood plains and canyon bottoms where they are subject to overflow.

15. Del Rio-Silver association

This association, which occurs on gently sloping and undulating summits or tops of plateaus and mesas in the northwestern part of the county, is relatively inextensive. It comprises an area of about 41,060 acres or slightly more than one percent of the county. It consists dominantly of deep upland soils developing in silty eolian and alluvial sediments.

Soils of this association are used for the grazing of livestock and wildlife. Moderate to good yields of forage are obtained under good management.

Dryland farming has been practiced unsuccessfully to a very limited extent on the soils of this association. Precipitation, however, is too limited to successfully farm these soils, hence none are under cultivation at the present time. Native vegetation includes big sagebrush, blue grama, western wheatgrass, and galleta. Thin stands of pinyon and juniper are also common, particularly near the outer edges of the association near the adjacent breaks or rough broken lands.

Soil Characteristics. Del Rio soils, the most extensive, are mainly on the crests or higher parts of the areas in this unit. They have a thin surface layer of brown noncalcareous loam. The subsoil is a moderately thick brown to reddish-brown clay loam that is leached free of lime in the upper part. Below the subsoil is a light reddish-brown calcareous loam or light clay loam with some visible lime in the form of fine soft masses and threads.

Silver soils are mainly on the level or nearly level areas and lower parts of side slope fans. They have a moderately thick surface layer of brown noncalcareous loam over a thick subsoil of light brown to brown clay or heavy silty clay loam which usually contains a few fine soft masses and threads of lime.

Also in this association are small inclusions of deep sandy soils and deep loamy soils, as well as soils of the Travessilla series. The Travessilla soils, which are shallow over sandstone, usually occur on the outer fringes or more sloping parts of this mapping unit.

Irrigation Potential. The major soils in this association have characteristics and properties favorable for their use as irrigated cropland. The small size and location on mesa tops and ridges of many of the areas in this association will, however, undoubtedly present problems in transporting irrigation water to these lands. Approximately 45 percent of the land in this association is in land class 2; 40 percent in class 3; and 15 percent in class 6.

16. La Fonda-Del Rio association

This association includes the area locally known as "Black Salt Valley" in the extreme southwestern part of San Juan County. It is the least extensive of all the soil associations, as it includes only an area of about 24,755 acres, or slightly less than one percent of the county. It is an area characterized by relatively broad, gently sloping piedmont slopes or upland valleys and moderately sloping to rolling uplands. The soils which are dominantly deep are developing in medium and moderately fine-textured sediments derived from Jurassic and Triassic Redbeds.

The dominant vegetation on the soils of this association consists of blue grama, galleta, Indian ricegrass, and big sagebrush. Thin and scattered stands of juniper trees are common on the shallow soils and at the higher elevations where this unit joins the Chuska Mountains. It is used for grazing of livestock.

Soil Characteristics. La Fonda soils, the most extensive in the association, occur on broad gently sloping alluvial fans and piedmont slopes. These soils have thin surface layers of reddish-brown noncalcareous loam. Their subsoil is a light reddish-brown, calcareous heavy loam. A substratum of light reddish-brown loam with a few small soft masses and seams of segregated lime is encountered at an average depth of 25 inches.

The Del Rio soils occupy the moderately sloping and rolling uplands in this association. They have a thin surface layer of brown noncalcareous loam. The subsoil is a moderately thick light reddish-brown to reddish-brown clay loam that is noncalcareous in the upper part. This is underlain by a light reddish-brown loam or clay loam that contains a few fine soft masses and seams of lime.

Rock Land, a miscellaneous land type, is also of minor importance in this association. It consists of a complex of sandstone and shale outcrops and associated shallow soils. A small acreage of deep alluvial soils on the flood plains of the larger intermittent drainages are also included in this unit. They are typically medium to moderately-fine textured.

Irrigation Potential. Although this is a relatively small unit, about 70 percent of the land in this association is suitable for irrigation. Approximately 50 percent of the land in this general soil area is in class 2; 10 percent in class 3; 10 percent in class 4; and 30 percent is nonirrigable, in class 6. This area, therefore, offers some potential for development of irrigated land, particularly if the irrigable land in this association is considered with that in adjacent counties.

17. Travessilla-Malposa-Rock Land association

This association is mainly in the foothills on the eastern slopes of the Chuska Mountains. It is characterized by steep and rough broken topography including rock outcrops, rock slides, and escarpments. The exposed rock areas on the steep slopes and escarpments are dominated by sandstone. Interspersed with the steep or very steeply sloping

rock outcrops and escarpments are relatively narrow valley floors and moderately steep to rolling uplands. It comprises an area of about 101,420 acres or slightly less than three percent of the county.

The soils of this association are best used as rangeland or recreational sites. They support a wide variety of native vegetation, including pinyon, juniper, big sage, bitter brush, snakeweed, chamiza, blue grama, sideoats grama, galleta, and Indian ricegrass.

Soil Characteristics. Travessilla soils, which are underlain by sandstone at depths of 8 to 20 inches, occur on the moderately steep to rolling upland areas. They have a thin surface layer of light brown sandy loam. This grades through soil material of similar color and texture until sandstone is encountered at depths ranging from 8 to 20 inches. It is common for the subsoil to contain small angular fragments of sandstone just above the bedrock.

Malposa soils are developing in a mantle of stony alluvial material overlying shale and sandstone on moderately steep to hilly uplands. In general they have a thin surface layer of brown, noncalcareous stony loam or stony fine sandy loam. Their subsoil is a light brown to brown clay or light clay that is calcareous in the lower part. A substratum of pinkish-white loam with a high lime content is at depths ranging from 18 to 30 inches.

Rock Land, a miscellaneous land type, is also an extensive component of this association. It is a complex of shallow soils, outcrops of sandstone and other sedimentary rocks. The sandstone outcrops commonly occur as vertical or nearly vertical exposures or ledges. A thin mantle of cobbly or stony soil material usually occurs between the outcrops of bedrock.

Other soils of lesser extent in this association include deep alluvial soils and shallow to moderately deep gravelly soils. The deep alluvial soils occupy the narrow valley bottoms. Although quite variable, they usually are medium to moderately-fine textured. The gravelly soils occur on upland ridges and slopes. Gravelly loams and gravelly clay loams are the more common textures.

Irrigation Potential. The potential for development of irrigated land in this association is very limited due to rough broken topography, steep slopes, and shallow soils. The limited acreage of soils suitable for irrigation commonly occurs in small tracts intermingled with large areas of nonirrigable soils.

18. Vamer-Rock Land association

This association includes the Chuska Mountains area in the southwestern part of the county. The altitude ranges from about 7,000 to slightly more than 9,300 feet, but is most commonly between 7,500 and 9,000 feet. It is characterized by a relatively broad gently sloping to rolling plateau or mountain top and very steeply sloping side slopes and escarpments. The rough, very steep, and mountainous topography typical of the side slopes is more extensive than that occurring on the ridge crests. The soils in this unit are developing dominantly in parent materials of sandstone origin. Other sedimentary rocks and eolian sediments have contributed minor amounts to the parent materials.

The association comprises an area of about 175,395 acres, or five percent of the county, and is best used for forestry, range, and recreation. The major soils in the unit are relatively productive and support good stands of native vegetation. The overstory vegetation consists dominantly of ponderosa pine, Gambel oak, and some pinyon and juniper. The more common grasses include Arizona fescue, mountain brome, bluegrass, needlegrass, and blue grama. They also support a number of desirable browse plants, such as mountain mahogany, cliffrose, vetch, and peavine. This association, with its capability to produce a wide variety of vegetation, provides good habitats for many species of wildlife. In addition to offering many opportunities for outdoor recreation, essentially all of the commercial timber harvested in San Juan County is produced on the soils of this association.

Fig. 12. Vamer-Rock Land association (No. 18). The soils of this association are suitable for many uses including forestry, range, recreation, and as habitat for wildlife. They are also important watershed lands.

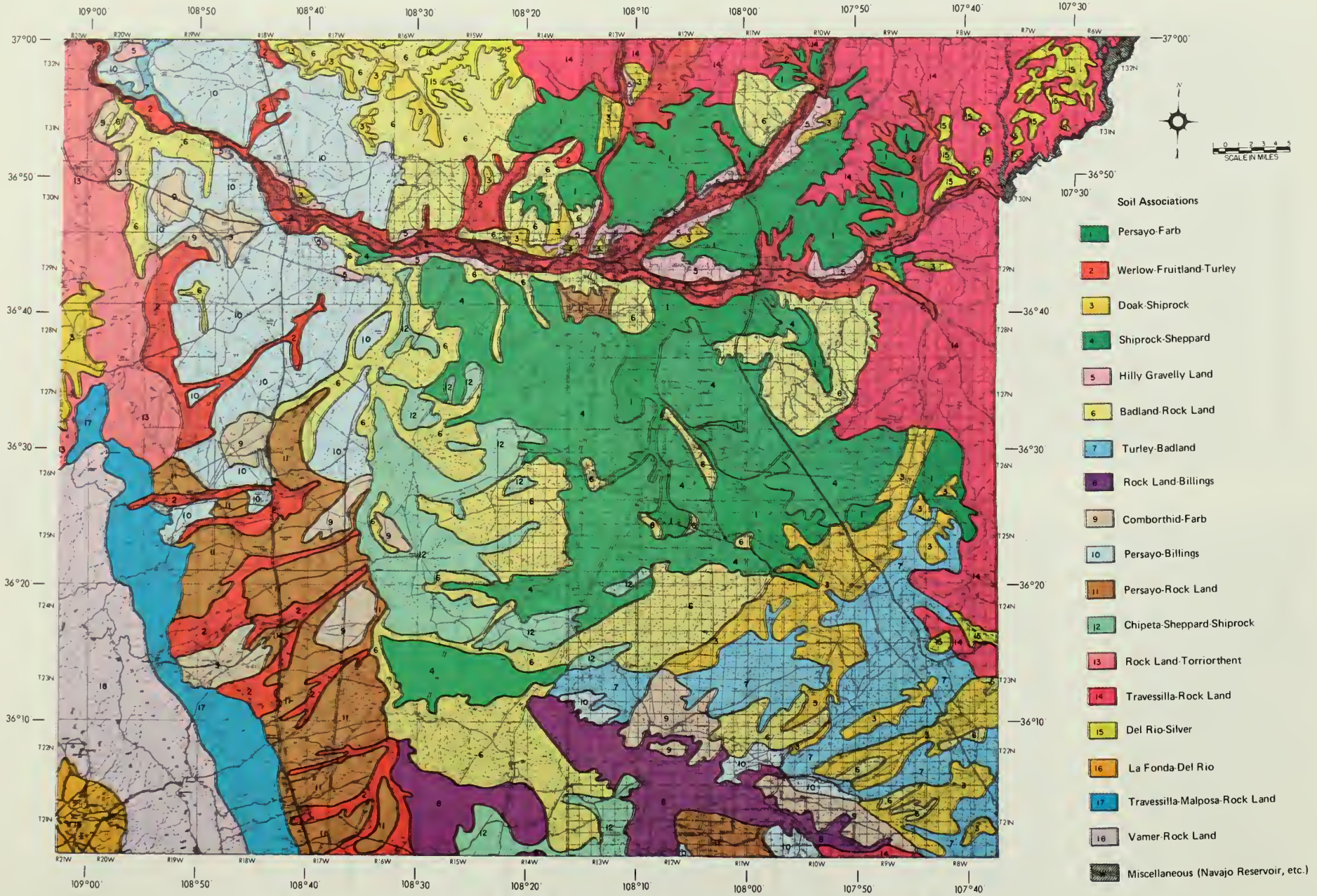

Fig. 1. General Soil Map of San Juan County, New Mexico

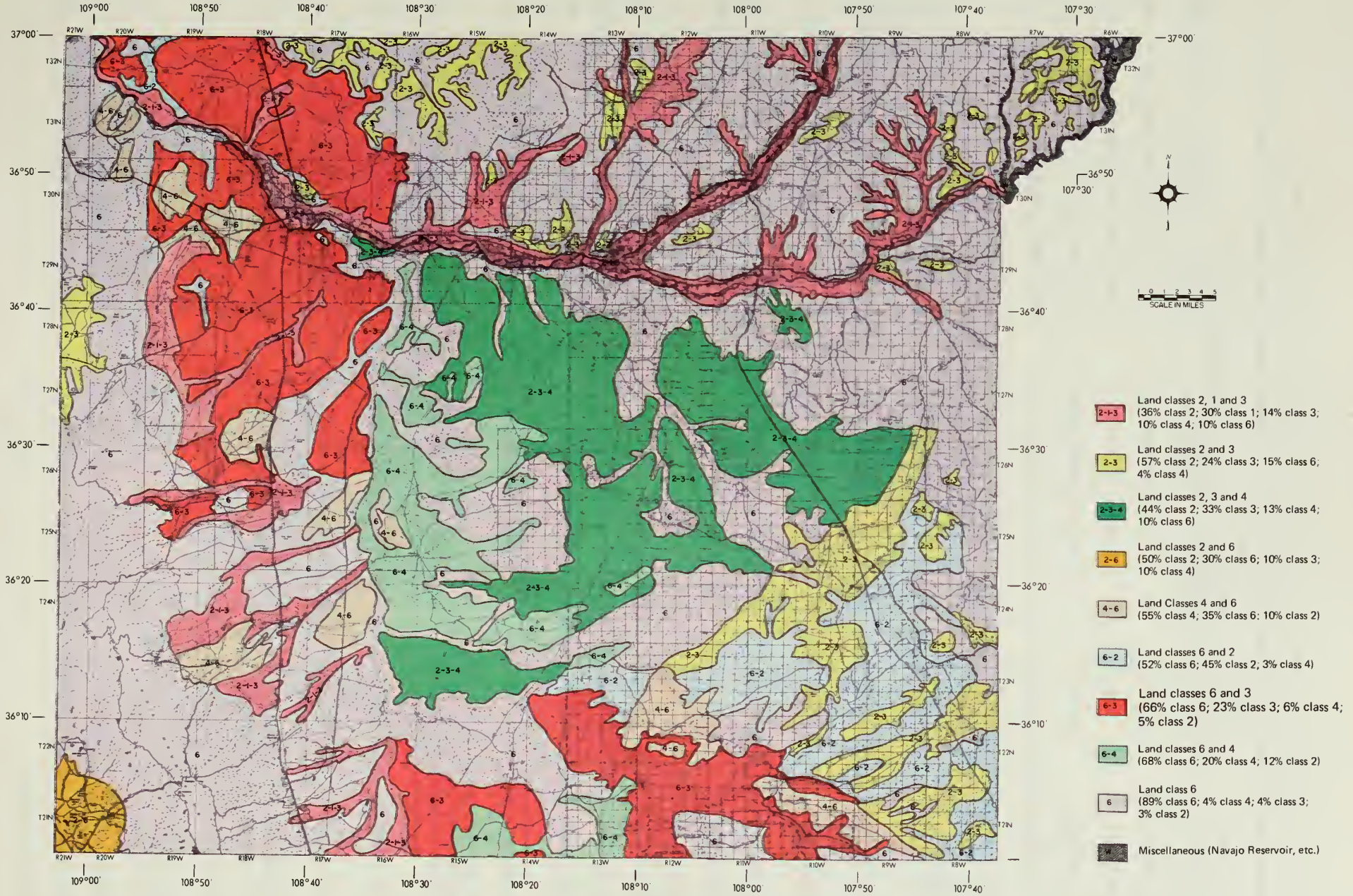

Fig. 2. Classification of Land for Irrigation in San Juan County, New Mexico

Table 4. Soil characteristics and quality of major soils in each soil association, San Juan County, New Mexico

Soil Map Symbol and Soil Association	Dominant Slope Range (percent)	Approximate Percent of Association	Pedologic Classification		Texture[1]
			Subgroup	Family	
1 Persayo-Farb					
Persayo silty clay loam	5-30	35	Typic Torriorthent	Loamy, mixed (calcareous), mesic, shallow	sil;sicl
Farb sandy loam	5-30	35	Lithic Torriorthent	Loamy, mixed (calcareous), mesic	sl; lfs
Sundown loamy sand	1- 9	10	Typic Torripsamment	Mixed, mesic	ls;sl
Shiprock fine sandy loam	0- 5	5	Typic Haplargid	Coarse-loamy, mixed, mesic	fsl, lfs
Badland	10-75+	10	(a miscellaneous land type)		
Rock Land	30-75+	5	(s miscellaneous land type)		
2 Werlow-Fruitland-Turley					
Werlow loam	0- 2	25	Aquic Ustifluvent	Fine-loamy, mixed (calcareous), mesic	l;vfsl
Fruitland sandy loam	0- 9	10	Typic Torriorthent	Coarse-loamy, mixed (calcareous), mesic	sl;scl;ls
Turley clay loam	0- 5	15	Typic Torriorthent	Fine-loamy, mixed (calcareous), mesic	cl;l
Azfield loam	0- 5	15	Typic Torriorthent	Fine-loamy, mixed (calcareous), mesic	l;vfsl
Sundown loamy sand	1- 9	5	Typic Torripsamment	Mixed; mesic	ls;sl
Other soils and land types		30			
3 Doak-Shiprock					
Doak loam	0- 6	35	Typic Haplargid	Fine-loamy, mixed, mesic	loam;scl
Shiprock fine sandy loam	0- 5	25	Typic Haplargid	Coarse-loamy, mixed, mesic	fsl;lfs
Grandview loam	0- 9	20	Typic Calciorthid	Fine-loamy, mixed, mesic	loam
Persayo silty clay loam	5-30	5	Typic Torriorthent	Loamy, mixed (calcareous), mesic, shallow	sil;sicl
Other soils and land types		15			
4 Shiprock-Sheppard					
Shiprock fine sandy loam	0- 5	35	Typic Haplargid	Coarse-loamy, mixed, mesic	fsl;lfs
Sheppard loamy sand	0-10	20	Typic Torripsamment	Mixed, mesic	ls;lfs
Nageesi sandy loam	0- 5	10	Typic Calciorthid	Coarse-loamy, mixed, mesic	sl
Kinnear fine sand loam and very fine sandy loam	0- 9	12	Typic Camborthid	Fine-loamy, mixed, mesic	fsl;vfsl
Typic Camborthids	0- 9	10	Typic Camborthid	Coarse loamy over sandy, mixed, mesic	fsl;lfs
Other soils and land types		13			
5 Hilly Gravelly Land					
Hilly gravelly land	5-75	75	(a miscellaneous land type)		
Doak loam	0- 5	5	Typic Haplargid	Fine-loamy, mixed, mesic	loam;scl
Grandview loam	0- 5	5	Typic Calciorthid	Fine-loamy, mixed, mesic	loam
Other soils and land types		15			

Surface Soil Features		Subsoil Features				Soil Depth	AWHC[5]
Color[2]	Reaction	Texture[1]	Color[2]	Permeability[3]	Substratum	(inches)	(inches)
Pale yellow	Strongly calc.	sicl	Light yellowish-brown	Slow	Shale	6 to 20	2 to 3
Pale brown	Weakly calc.	sl	Pale brown	Rapid	Sandstone	10 to 20	1 to 2
Light brownish-gray	Weakly calc.	ls	Light brownish-gray	Very rapid	Sandy alluvium	60 or more	3 to 4
Light brown	Noncalcareous	scl;fsl	Reddish-brown	Moderate	Sandy eolian sediments	60 or more	5 to 6
Pale brown or grayish-brown	Calcareous	l;vfsl;scl	Light yellowish-brown or light brownish-gray	Moderate	Loamy alluvium	60 or more	7 to 8
Yellowish-brown or brown	Calcareous	sl	Yellowish-brown or pale brown	Rapid	Sandy alluvium	60 or more	5
Grayish-brown	Calcareous	cl	Yellowish-brown to olive brown	Slow	Loamy alluvium	60 or more	7 to 8
Brown or grayish-brown	Calcareous	l;vfsl;scl	Brown	Moderate	Loamy alluvium	60 or more	7 to 8
Light brownish-gray	Weakly calc.	ls;s	Light brownish-gray	Very rapid	Sandy alluvium	60 or more	2.5 to 4
Brown	Noncalcareous	cl	Brown	Moderate	Loamy alluvium	60 or more	8
Light brown	Noncalcareous	fsl	Reddish-brown	Moderate	Sandy eolian sediments	60 or more	5 to 6
Brown	Strongly calc.	loam;cl	Light brown	Moderate	Strongly calcareous loams	60 or more	6
Pale yellow	Strongly calc.	sicl	Light yellowish-brown	Slow	Shale	8 to 20	1 to 3
Light brown	Noncalcareous	fsl	Reddish-brown	Moderate	Sandy eolian sediments	60 or more	5 to 6
Pale brown	Weakly calc.	ls	Very pale brown	Rapid to very rapid	Sandy eolian sediments	60 or more	3 to 4
Reddish-yellow	Strongly calc.	sl	Reddish-yellow; white	Moderate	Limy sediments or soft caliche	15 to 20	4
Brown	Slightly calc.	scl;l;vfsl	Reddish-yellow	Moderate	Sandy eolian and alluvial sediments	60 or more	4 to 6
Light brown	Noncalcareous	scl;sand	Light reddish-brown	Rapid	Sandy eolian sediments	60 or more	3
Brown	Noncalcareous	cl	Brown	Moderate	Loamy alluvium	60 or more	8
Brown	Strongly clac.	loam;cl	Light brown	Moderate	Strongly calcareous loams	60 or more	6

Table 4. (Continued)

Soil Map Symbol and Soil Association	Dominant Slope Range (percent)	Approximate Percent of Association	Pedologic Classification		
			Subgroup	Family	Texture[1]
6 Badland-Rockland					
Badland	0-75+	50	(a miscellaneous land type)		
Rock Land		20	(a miscellaneous land type)		
Alluvial land	1- 9	10	(a miscellaneous land type)		
Persayo silty clay loam	5-30	5	Typic Torriorthent	Loamy, mixed (calcareous), mesic, shallow	sil;sicl
Other soils and land types		15			
7 Turley-Badland					
Turley clay loam	0- 5	35	Typic Torriorthent	Fine-loamy, mixed (calcareous), mesic	loam;cl
Farb sandy loam	5-30	20	Lithic Torriorthent	Loamy, mixed (calcareous), mesic	sl;lfs
Badland	30-75+	20	(a miscellaneous land type)		
Azfield loam	0- 5	10	Typic Torriorthent	Fine-loamy, mixed (calcareous), mesic	loam
Other soils and land types		15			
8 Rock Land-Billings					
Rock Land	30-75	55	(a miscellaneous land type)		
Billings silty clay loam	0- 5	15	Typic Torrifluvent	Fine-silty, mixed (calacreous), mesic	sil;sicl
Christianburg like clay	0- 3	10	Typic Torrifluvent	Fine, mixed (calcareous), mesic	sicl;clay
Farb sandy loam	3-30	10	Lithic Torriorthent	Loamy, mixed (calcareous), mesic	sl;lfs
9 Camborthid-Farb					
Typic Camborthids	1- 9	50	Typic Camborthids	Coarse-loamy, mixed, mesic	fsl;vfsl
Farb sandy loam	3-30	30	Lithic Torriorthent	Loamy, mixed (calcareous), mesic	fsl, lfs
Other soils and land types		20			
10 Persayo-Billings					
Persayo silty clay	0-15	60	Typic Torriorthent	Loamy, mixed (calcareous), mesic, shallow	sil;sicl
Billings silty clay loam	0- 5	25	Typic Torrifluvent	Fine-silty, mixed (calcareous), mesic	sil;sicl
Christianburg-like clay	0- 3	5	Typic Torrifluvent	Fine, mixed (calcareous), mesic	sicl; clay
Other soils and land types		10			
11 Persayo-Rock Land					
Persayo silty clay loam	1-15	40	Typic Torriorthent	Loamy, mixed (calcareous), mesic, shallow	sil;sicl
Typic Camborthids	1- 8	20	Typic Camborthid	Coarse-loamy, mixed, mesic	fsl;vfsl
Rock Land	30-75	20	(a miscellaneous land type)		
Other soils and land types		20			
12 Chipeta-Sheppard-Shiprock					
Chipeta clay	0-15	58	Typic Torriorthent	Clayey, mixed (calcareous), mesic, shallow	sicl;clay
Sheppard loamy sand	1- 9	17	Typic Torripsamment	Mixed mesic	ls,lfs
Shiprock fine sandy loam	0- 5	10	Typic Haplargid	Coarse-loamy, mixed, mesic	fs,lfs
Other soils and land types		15			

Surface Soil Features		Subsoil Features				Soil Depth	AWHC[5]
Color[2]	Reaction	Texture[1]	Color[2]	Permeability[3]	Substratum	(inches)	(inches)
Pale yellow	Strongly calc.	sicl	Light yellowish-brown	Slow	Shale	8 to 20	2 to 3
Light brownish-gray	Calcareous	cl	Light brownish-gray	Slow	Loamy alluvium	60 or more	8
Pale brown	Weakly calc.	sl	Very pale brown	Rapid	Sandstone	10 to 20	1 to 2
Brown or light olive brown	Calcareous	loam	Brown or olive brown	Moderate	Loamy alluvium	60 or more	7
Light gray	Calcareous	sicl	Light brownish-gray	Slow	Loamy alluvium	60 or more	8
Light brownish-gray	Calcareous	clay	Light brownish-gray	Very slow	Clayey alluvium	60 or more	
Pale brown	Weakly calc.	sl	Very pale brown	Rapid	Sandstone	10 to 20	1 to 2
Light brown	Weakly calc.	fsl;vfsl	Light brown	Moderate	Sandstone	20 to 40	3 to 4
Light brown	Weakly calc.	sl	Very pale brown	Rapid	Sandstone	10 to 20	1 to 2
Pale yellow	Calcareous	sicl	Light yellowish-brown	Slow	Shale	6 to 20	2 to 3
Light gray	Calcareous	sicl	Light brownish-gray	Slow	Loamy alluvium	60 or more	8
Light brownish-gray	Calcareous	clay	Light brownish-gray	Very slow	Clayey alluvium	60 or more	7
Pale yellow	Calcareous	sicl	Light yellowish-brown	Slow	Shale	6 to 20	2 to 3
Light brown	Weakly calc.	fsl,vfsl	Light brown	Moderate	Sandstone	20 to 40	3 to 4
Light yellowish-brown	Strongly calc.	clay	Light yellowish-brown	Very slow	Shale	10 to 20	2 to 3
Pale brown	Weakly calc.	ls	Very pale brown	Rapid to very rapid	Sandy eolian sediments	60 or more	3 to 4
Light brown	Noncalcareous	scl	Reddish-brown	Moderate	Eolian sediments	60 or more	5 to 6

Table 4. (Continued)

Soil Map Symbol and Soil Association	Dominant Slope Range (percent)	Approximate Percent of Association	Pedologic Classification		
			Subgroup	Family	Texture[1]
13 Rock Land-Torriorthent					
Rock Land	30-75	45	(a miscellaneous land type)		
Lithic Torriorthents	3-30	35	Lithic Torriorthent	Loamy, mixed (calcareous), mesic	loam
Other soils and land types		20			
14 Travessilla-Rock Land					
Travessilla sandy loam	3-30	40	Lithic Ustic Torriorthent	Loamy, mixed (calcareous), mesic	sl
Rock Land	30-75	25	(a miscellaneous land type)		
Ustic Torriorthents	3-30	10	Ustic Torriorthent	Loamy, mixed (calcareous), mesic, shallow	cl;sicl
Del Rio loam	1- 9	6	Ustollic Haplargid	Fine-silty, mixed, mesic	loam;sil
Other soils and land types		19			
15 Del Rio-Silver					
Del Rio loam	1- 9	45	Ustollic Haplargid	Fine-silty, mixed, mesic	loam;sil
Silver loam	0- 5	30	Ustollic Haplargid	Fine, mixed, mesic	loam;sil
Travessilla sandy loam	3-30	10	Lithic Ustic Torriorthent	Loamy, mixed (calcareous), mesic	sl
Other soils and land types		15			
16 La Fonda-Del Rio					
La Fonda loam	1- 9	50	Ustollic Camborthid	Fine-loamy, mixed, mesic	loam
Del Rio loam	9-30	30	Ustollic Haplargid	Fine-silty, mixed, mesic	loam;sil
Other soils and land types		20			
17 Travessilla-Malposa-Rock Land					
Travessilla sandy loam	5-30	30	Lithic Ustic Torriorthent	Loamy,mixed calcareous), mesic	sl
Malposa loam	5-30	30	Ustollic Haplargid	Fine, mixed mesic	loam
Rock Land		25	(a miscellaneous land type)		
Other soils and land types		15			
18 Vamer-Rock Land					
Vamer loam	1- 9	25	Lithic Eutroboralf	Clayey, mixed	l;col
Rock Land	30-75+	20	(a miscellaneous land type)		
Typic Eutroboralfs, steep phase	5-75+	25	Typic Eutroboralf	Fine-loamy, mixed	loam
Typic Eutroboralfs, gently sloping phase	0- 9	10	Typic Eutroboralf	Fine-loamy, mixed	loam
Other soils and land types		20			

[1]Abbreviations used for textural classes are:

ls - loamy sand
lfs - loamy fine sand
sl - sandy loam
fsl - fine sandy loam
vfsl - very fine sandy loam
l - loam
col - cobbly loam
sil - silt loam
scl - sandy clay loam
cl - clay loam
sicl - silty clay loam

[2]Other abbrevaitions
cal. - calcareous

Surface Soil Features		Subsoil Features				Soil Depth	AWHC[5]
Color[2]	Reaction	Texture[1]	Color[2]	Permeability[3]	Substratum	(inches)	(inches)
Light brown	Calcareous	loam;cl	Reddish-brown	Moderate	Sandstone	10 to 20	2 to 3
Light brownish-gray	Weakly calc.	sl	Pale brown	Rapid	Sandstone	8 to 20	1 to 2
Grayish-brown	Calcareous	cl;sicl	Grayish-brown	Slow	Shale	10 to 20	2 to 3
Brown	Noncalcareous	cl;sicl	Reddish-brown	Moderate to slow	Loamy eolian	60 or more	8
Brown	Noncalcareous	sicl;cl	Reddish-brown	Moderate to slow	Loamy eolian	60 or more	8
Brown	Noncalcareous	clay;sicl	Light brown to brown	Slow	Loamy eolian	60 or more	8
Light brownish-gray	Weakly calc.	sl	Pale brown	Rapid	Sandstone	10 to 20	1 to 2
Reddish-brown	Noncalcareous	loam;cl	Light reddish-brown	Moderate	Loamy alluvium	60 or more	7
Brown	Noncalcareous	cl;sicl	Reddish-brown	Slow	Loam and clay loam	60 or more	8
Light brown	Weakly calc.	sl	Pale brown	Rapid	Sandstone	10 to 20	1 to 2
Brown	Noncalc.	cl,clay	Brown	Slow	Strongly calcareous loams	60 or more	6
Brown or grayish-brown	Neutral	sc;clay	Brown	Very slow	Sandstone	10 to 20	2 to 3
Grayish-brown	Neutral	l;cl;scl	Yellowish-brown	Moderate	Loamy colluvial and alluvial sediments	60 or more	6 to 8
Very dark brown	Neutral	l;scl	Brown	Moderate	Loamy colluvial and alluvial sediments	60 or more	6 to 8

[3]Permeability classes and approximate rates per hour:
Very slow - less than 0.2 inches
slow - 0.2 to 0.6 inches
moderate - 0.6 to 2.0 inches
rapid - 2.0 to 6.0 inches
very rapid - Over 6.0

[4]Depth of effective soil material.

[5]AWHC - Available water-holding capacity (estimated to a depth of 4 feet or for effective soil material if less than 4 feet).

Soil Characteristics. Vamer soils, which are shallow, are forming residually in materials weathered mainly from sandstone. They commonly occur on gently sloping and undulating ridge crests and on the outer edges of mountain plateau or mesa tops. These soils have a brown to grayish-brown, neutral, loam or cobbly loam surface layer over a brown sandy clay or clay subsoil. Sandstone or sandstone interbedded with strata of shale occurs at a depth ranging from about 10 to 20 inches. Coarse fragments are mainly sandstone and usually comprise 5 to 25 percent of the surface layer and 5 to 15 percent of the subsoil.

Rock Land, a miscellaneous land type, is common on the steep canyon walls, escarpments, and the steep, rough, and broken mountain side slopes. It consists dominantly of a complex of shallow soils, and outcrops of sandstone and other types of sedimentary rocks. The outcrops of bedrock commonly occur as vertical or nearly vertical exposures or ledges on the steep to very steep slopes. A thin mantle of soil with highly variable characteristics generally occurs between the rock outcrops. Stones and boulders are common over much of the land surface. Although the soils intermingled with rock outcrops are generally shallow, small areas or pockets of these soils may be moderately deep or deep.

The other soils of importance in this association have not been identified at the series level in the classification system. These include Typic Eutroboralfs, steep phase, and Typic Eutroboralfs, gently sloping phase. The Typic Eutroboralfs, steep phase, consists of deep and dark-colored soils on steep mountain slopes. These soils have a thick grayish-brown loam surface layer that is neutral in reaction. This is usually underlain to a depth of four feet or more by a yellowish-brown loam or light clay loam. Strata of sandy loam or fine sandy loam may also occur in the substratum. A few outcrops of sandstone occur occasionally on some of the steeper slopes.

The Typic Eutroboralfs, gently sloping phase, typically occur on the high mesa tops or mountain plateaus. They occupy the nearly level to gently sloping open park areas or mountain valleys. These soils have thick surface layers of very dark brown noncalcareous loam. Their subsoil is a brown noncalcareous sandy clay loam or loam. Sandstone bedrock usually occurs at depths greater than 60 inches.

Also in this association are small areas of unclassified shallow soils and deep alluvial soils. The shallow soils resemble the Vamer soils, but are coarser textured. These soils usually have a moderately thick surface layer of very dark gray noncalcareous loam and a subsoil of brown fine sandy loam or loam. They are generally underlain by sandstone bedrock at depths of less than 20 inches. The deep alluvial soils usually occur on narrow flood plains contiguous to intermittent drainages. Although normally quite variable, in general, they are deep, moderately permeable and range in texture from medium to moderately fine.

Irrigation Potential. The potential for the development of irrigated land in this association is very limited. The soils with characteristics suitable for irrigation occur on the broad plateaus or mountain tops. The growing season and choice of crop will be very limited at these high elevations, which range from 8,000 to 9,000 feet.

SUITABILITY OF SOILS FOR IRRIGATION

In this section the extent, location, and suitability of soils for irrigation, as well as their placement in the various irrigation land classes are discussed. The acreage of irrigable and nonirrigable land in each of the 18 soil associations is shown in table 5. These estimates and percentages of land in each of the five land classes were determined on the basis of the kinds of soils occurring in the soil associations.

The approximate distribution of the various land classes in San Juan County is shown on the irrigation land class map (figure 2). This map was based on the soil association map (figure 1) and the acreages of land classes in each of the soil associations (table 5). The land class or classes shown comprise more than 75 percent of the delineated area. No land class was shown that did not comprise at least 10 percent or more of the area identified on the map. In those cases where more than one land class is shown, the most extensive class is indicated first, followed in order by those of lesser extent. The small scale of the irrigation land class map precludes the possibility of showing small areas of land with different capabilities for irrigation. For example, the large and extensive areas of class 6 land may contain small tracts of land suitable for irrigation. Because of the limitation of map scale, these small tracts that differ in capability for irrigation are not shown.

The irrigation land classes provide a relative rating of the suitability of land for irrigation. Class 1 land has few or no limitations for irrigation. The limitations for use of land under irrigation increase from 1 through 4 with class 4 having severe limitations for such use. Class 6 land is nonirrigable. An analysis of the irrigation land classification data, as shown in table 5 indicates that the following soil

Table 5. Estimated acreage and approximate percentage of land in each irrigation land class by soil association, San Juan County

Soil Map Symbol and Soil Association	Class 1		Class 2		Class 3		Class 4		Classes 1 to 4 Total		Class 6		Grand Total		Principal Limiting Factors
	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent	
1 Persayo-Farb															
Persayo silty clay loam											92,929		92,929		Soil depth; AWHC*
Farb sandy loam											92,929		92,929		Soil depth; AWHC*
Sundown loamy sand							26,551		26,551				26,551		AWHC; slope
Shiprock fine sandy loam			13,275						13,275				13,275		AWHC; slope
Badland											26,551		26,551		Topography and soil
Rock Land											13,275		13,275		
Total			13,275	5			26,551		39,826	15	225,684	85	265,510	8	
2 Werlow-Fruitland-Turley															
Werlow loam	36,276		19,533		13,952				68,761				69,761		Wetness; salinity
Fruitland sandy loam			19,533		8,371				27,904				27,904		AWHC; slope
Turley clay loam	19,533		19,533		2,790				41,856				41,856		Slope; salinity
Azfield loam	13,952		27,905						41,857				41,857		Slope
Other soils and land types	13,953		13,953		13,952		27,904		69,762		27,905		97,667		
Total	83,714	30	100,457	36	39,065	14	27,904	10	251,140	90	27,905	10	279,045	8	
3 Doak-Shiprock															
Doak loam			47,843		19,137				66,980				66,980		Slope
Shiprock fine sandy loam			47,842						47,842				47,842		AWHC; slope
Grandview loam			19,137		19,137				38,274				38,274		Slope
Persayo silty clay loam											9,568		9,568		Soil depth; AWHC
Other soils and land types							9,569		9,569		19,137		28,706		
Total			114,822	60	38,274	20	9,569	5	162,665	85	28,705	15	191,370	5	
4 Shiprock-Sheppard															
Shiprock fine sandy loam			123,225						123,225				123,225		AWHC; slope
Sheppard loamy sand					70,414				70,414				70,414		AWHC; slope
Kinnear fine sandy loam			31,686		10,562				42,248				42,248		AWHC; slope
Nagessi sandy loam					35,207				35,207				35,207		AWHC; soil depth
Typic Camborthids							35,207		37,207				37,207		
Other soils and land types							10,562		10,562		35,207		45,769		
Total			154,911	44	116,183	33	45,769	13	316,863	90	35,207	10	352,070	10	
5 Hilly Gravelly Land															
Hilly gravelly land											32,700		32,700		Topography and soil
Doak loam			2,180						2,180				2,180		Slope
Grandview loam			2,180						2,180				2,180		Slope
Other soils and land types											6,540		6,540		
Total			4,360	10					4,360	10	39,240	90	43,600	1	
6 Badland-Rock Land															
Badland											260,128		260,128		Topography and soil
Rock Land											104,051		104,051		Topography and soil
Alluvial Land											52,025		52,025		Soil; overflow; erosion
Persayo silty clay loam											26,018		26,013		Soil depth; AWHC
Other soils and land types			10,405						10,405		67,633		78,038		
Total			10,405	2					10,405	2	509,850	98	520,255	15	

Table 5. (Continued)

Soil Map Symbol and Soil Association	Class 1		Class 2		Class 3		Class 4		Classes 1 to 4 Total		Class 6		Grand Total		Principal Limiting Factors
	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent	
7 Turley-Badland															
Turley clay loam			60,020						60,020				60,020		Slope
Farb sandy loam											34,297		34,297		Soil depth; AWHC
Badland											34,297		34,297		Topography and soil
Azfield loam			17,148						17,148				17,148		Slope
Other soils and land types							5,145		5,145		20,578		25,723		
Total			77,168	45			5,145	3	82,313	48	89,172	52	171,485	5	
8 Rock Land-Billings															
Rock Land											62,375		62,375		Topography and soil
Billings silty clay loam					17,012				17,012				17,012		Salinity; overflow
Christianburg-like clay							11,341		11,341				11,341		Salinity; permeability
Farb sandy loam											11,341		11,341		Soil depth; AWHC
Other soils and land types					2,268		3,402		5,670		5,671		11,341		
Total					19,280	17	14,743		34,023	30	79,387	70	113,410		
9 Camborthid-Farb															
Typic Camborthids							57,240		57,240				57,240		Barrier; AWHC
Farb sandy loam											34,344		34,344		Soil depth; AWHC
Other soils and land types			11,448				5,724		57,172		5,724		22.907		
Total			11,448	10			62,964	55	74,412	65	40,068	35	114,480	3	
10 Persayo-Billings															
Persayo silty clay loam											194,481		194,481		Soil depth; AWHC
Billings silty clay loam					81,034				81,034				81,034		Salinity; overflow
Other soils and land types			22,690				9,724		32,414		16,206		48,620		
Total			22,690	7	81,034	25	9,724	3	113,448	35	210,687	65	324,135	9	
11 Persayo-Rock Land															
Persayo silty clay loam											80,276		80,276		Soil depth; AWHC
Typic Camborthids							20,069		20,069		20,069		40,138		Barrier; AWHC
Rock Land											40,138		40,138		Topography and soil
Other soils and land types			8,028		8,028		4,013		20,069		20,069		40,138		
Total			8,028	4	8,028	4	24,082	12	40,138	20	160,552	80	200,690	6	
12 Chipeta-Sheppard-Shiprock															
Chipeta clay											88,053		88,053		Soil depth; AWHC
Sheppard loamy sand							25,808		25,808				25,808		AWHC; erosion; slope
Shiprock fine sandy loam			15,182						15,182				15,182		AWHC; slope
Other soils and land types			3,036				4,554		7,590		15,182		22,772		
Total			18,218	12			30,362	20	48,580	32	103,235	68	151,815	4	
13 Rock Land-Torriorthent															
Rock Land											53,318		53,318		Topography and soil
Lithic Torriorthents											41,470		41,470		Soil depth; AWHC
Other soils and land types							5,924		5,924		17,773		23,697		
Total							5,924	5	5,924	5	112,561	95	118,485	3	

Table 5. (Continued)

Soil Map Symbol and Soil Association	Class 1		Class 2		Class 3		Class 4		Classes 1 to 4 Total		Class 6		Grand Total		Principal Limiting Factors
	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent	
14 Travessilla-Rock Land															
Travessilla sandy loam											132,068		132,068		Soil depth; AWHC
Rock Land											82,543		82,543		Topography and soil
Ustic Torriorthents											33,017		33,017		Soil depth; AWHC
Del Rio loam			6,603		13,207				19,810				19,810		Slope
Other soils and land types			9,905		9,905		9,905		29,715		33,017		62,732		
Total			16,508	5	23,112	7	9,905	3	49,525	15	280,645	85	330,170	9	
15 Del Rio-Silver															
Del Rio loam			6,159		12,318				18,477				18,477		Slope
Silver loam			12,318						12,318				12,318		Permeability; slope
Travessilla sandy loam											4,106		4,106		Soil depth; AWHC
Other soils and land types					4,106				4,106		2,053		6,159		
Total			18,477	45	16,424	40			34,901	85	6,159	15	41,060	1	
16 La Fonda-Del Rio															
La Fonda loam			9,902		2,475				12,377				12,377		Slope
Del Rio loam							2,476		2,476		4,951		7,427		Slope; barrier
Other soils and land types			2,475						2,475		2,476		4,951		
Total			12,377	50	2,475	10	2,476	10	17,328	70	7,427	30	24,755	1	
17 Travessilla-Malposa-Rock Land															
Travessilla sandy loam											30,426		30,426		Soil depth; AWHC
Malposa loam											30,426		30,426		Slope; barrier
Rock Land											25,355		25,355		Topography and soil
Other soils and land types					5,071		5,071		10,142		5,071		15,213		
Total					5,071	5	5,071	5	10,142	10	91,278	90	101,420	3	
18 Vamer-Rock Land															
Vamer soils											43,849		43,849		Soil depth; AWHC
Rock Land											35,079		35,079		Topography and soil
Typic Eutroboralfs, steep											43,849		43,849		Slope
Typic Eutroboralfs, gently sloping					17,539				17,539				17,539		Slope; drainage
Other soils and land types					8,770				8,770		26,309		35,079		
Total					26,309	15			26,309	15	149,086	85	175,395	5	
Miscellaneous (Navajo Reservoir and other water areas)											11,050	100	11,050	**	
Grand Total	83,714	2	583,144	16	375,255	11	280,189	8	1,322,302	37	2,207,898	63	3,530,200		

[1]Percentages are of association except grand total, which is percent of county.

*AWHC is abbreviation for available water-holding capacity.

**Less than 0.5 percent.

associations contain a high percentage of land suitable for irrigation.

2. Werlow-Fruitland-Turley association
3. Doak-Shiprock association
4. Shiprock-Sheppard association
15. Del Rio-Silver association
16. La Fonda-Del Rio association

These five soil associations (figure 1) contain slightly more than 782,800 acres of irrigable land, or approximately 59 percent of the 1,322,300 acres classified as suitable for irrigation in San Juan County. They also contain all the class 1, about 69 percent of the class 2, and 57 percent of the class 3. Although a part of this potentially irrigable land occurs on small tracts and is widely distributed, there is considerable potential for expansion of irrigated land in the areas occupied by the five soil associations listed, as far as the availability of suitable soils is concerned. The largest tracts of irrigable land occur in soil associations 3 and 4. A few relatively large bodies of irrigable land also occur in the northern and western parts of soil association 2.

The Shiprock-Sheppard association (No. 4) has the largest continuous tracts of irrigable land, and contains about 316,800 acres of land suitable for cropland use under irrigation. However, approximately 13 percent of this acreage is in class 4 because of the sandy nature of the soils, their low moisture-retention capacity, and undulating or rolling topography, or because they are underlain by sandstone and shale at moderate depths.

In addition to the class 4 land this association contains approximately 44 percent class 2 land and 33 percent class 3 land. The lands in these classes have sufficient productive capacity to support sustained irrigation, and they are of sufficient quality to warrant consideration for irrigation development.

Approximately 90 percent (279,045 acres) of the Werlow-Fruitland-Turley (No. 2) association consists of irrigable land. In general, the major soils in this association are well suited for use as cropland under irrigation. This is reflected in the irrigation land classification as about 30 percent of the land in this association is in class 1 and 36 percent in class 2. Although there is considerable potential in this association for the development of additional irrigated land, it is not as great as the acreage tends to indicate. The majority of the presently irrigated (49,000 acres) land occurs in this association. In addition, a significant part of this association is in urban areas, industrial sites, highways, roads, and other built-up areas. The lands in these uses were not deducted from the acreage that is indicated as suitable for irrigation. Another item that will tend to limit the development of irrigated land in this association is the location and wide distribution of the land suitable for irrigation.

About 85 percent of the land in the Doak-Shiprock (No. 3) association is suitable for irrigation. This association also includes numerous small, isolated tracts of land which will present water transportation problems. A few relatively large tracts of irrigable land in this association occur in the southeastern part of the county. The major soils in this unit, however, are in land class 2, hence they are well suited for use as cropland under irrigation. With good irrigation and farming practices, these soils have sufficient productive capacity to support irrigation. As indicated previously, the small size and location of many of the tracts of land suitable for irrigation will undoubtedly tend to limit their use for this purpose.

The Del Rio-Silver (No. 15) association, which is located on high mesas and plateaus in the northeastern part of the county, contains about 34,900 acres of irrigable land. This represents about 85 percent of the association of which approximately 45 percent is in land class 2 and 40 percent in class 3. The location and relatively small size of many of these tracts of irrigable land are factors that will need to be considered in determining the feasibility of developing these lands.

The La Fonda-Del Rio (No. 16) association in the southwestern part of the county was estimated to about 17,328 acres of irrigable land. Approximately 50 percent of the acreage is in land class 2, 10 percent in class 3 and 10 percent in class 4, for a total of about 70 percent of the land in this association. Although the amount of land in this unit suitable for irrigation is small it may warrant consideration if considered with that in adjacent counties.

A summary of the estimated acreage and percentage of land in the various irrigation land classes for these five soil associations with the highest percentages of irrigable land is shown in table 5.

In the remainder of the general soil areas, the percentage of irrigable land ranges from little or none in association 6 to 65 percent in association 9 (see table 5). Although the total acreage (about 525,000 acres) of irrigable land in these associations is relatively large, the opportunity for any significant expansion of irrigated land is very limited or nonexistent. There are a number of factors that undoubtedly will tend to preclude the development of these lands for irrigation. A major item is the wide distribution and common

occurrence of the soils classified as suitable for irrigation in small tracts intermingled with large areas of nonirrigable lands. Another item of importance is the limited capabilities of many of the soils involved. For example, soil association 9, which contains a relatively high percentage of irrigable land, is dominated by soils poorly suited to irrigation. Approximately 55 percent of the irrigable land in this association is in land class 4.

The problems and hazards inherent in the irrigation of soils developing on shale or in materials of shale origin will also tend to limit irrigation development. Soil association 10, which is representative of this condition, contains over 113,448 acres of land classified as suitable for irrigation. These lands occupy swales and low-lying positions in association with the shallow soils of the Persayo series. The irrigation or transportation of irrigation water in unlined ditches on the Persayo and associated soils underlain by shale will tend to create unfavorable drainage conditions and harmful salt accumulations in the soils now classified as irrigable. Therefore, in addition to the problems inherent in the transportation of irrigation water to small isolated tracts, these soils are susceptible to the accumulation of salts and development of unfavorable drainage conditions.

There will also be a need to protect those lands occurring on the flood plains of intermittent drainages from damaging overflows and gully erosion if developed for irrigation. In summation, therefore, it appears very unlikely that there will be any significant increase of irrigated land in those parts of San Juan County not included in the five soil associations referred to in this section on suitability of soils for irrigation.

Of the 1,322,300 acres of land in San Juan County classified as suitable for irrigation, about 6 percent is class 1; 44 percent is class 2; 29 percent is class 3; and 21 percent is class 4.

SUITABILITY OF SOILS FOR ENGINEERING AND RELATED USES

In this section information is provided on engineering properties and uses of soils as construction material and as a support of various kinds of structures. The information provided is in tabular form and in accordance with soil associations shown on the small scale soil map (figure 1). Selected engineering properties, engineering classifications, and estimates of the suitability of soils for specified engineering uses are indicated for the major soils in each soil association. This correlation of engineering data and soil properties according to soil associations or general soil areas can be useful in estimating the suitability of certain areas for engineering purposes. The information on general soil problems, limitations, and hazards can also be helpful in selection of areas for various engineering structures or practices.

The data presented here will not eliminate the need for on-site sampling and testing of sites for design and construction of specific engineering works and uses. This is particularly true at those sites of specific engineering works involving heavy loads or where excavations are deeper than the soil depths reported here. In addition, the general soil map does not delineate or specifically show the location of the individual kinds of soil.

The general soil map is useful, however, for planning more detailed investigations and for suggesting the kinds of problems that may be expected in each of the soil associations.

Engineering Soil Groups and Estimated Soil Properties

Estimates of selected soil properties and engineering groups of importance in engineering are given in table 6. Information taken from the detailed soil surveys, knowledge of the soil types of the county, and a limited amount of laboratory test data were used as a basis for estimates.

A brief explanation of some of the terms used in table 6 follows:

The "USDA texture" is determined by the relative proportions of sand, silt, and clay in the soil mass. It is the standard procedure used by the U.S. Department of Agriculture to classify soils according to texture.

Highway engineers generally classify soil material in accordance with the system approved by the American Association of State Highway Officials.[7] In this system (AASHO), classification is based on the gradation, liquid limit, and plasticity index of the soil. Highway performance has been related to this system of classification. All soil materials are classified in seven principal groups. The groups range from A-1 (gravelly soils of high bearing capacity, the best soils for subgrades) to A-7 (clay soils having low strength when wet, and the poorest soils for subgrades).

Many engineers prefer to use the Unified soil classification system established by the Waterways

[7] American Association of State Highway Officials, 1955 Standard Specifications for Highway Materials and Methods of Sampling and Testing. Ed. 7, part 1.

Table 6. Engineering soil groups and estimated soil properties, San Juan County, New Mexico

Soil Map Symbol and Soil Association	Depth from Surface	Classification			Percentage Passing Sieve--			Range in Permeability	Shrink-swell Potential
		USDA texture	Unified	AASHO	No. 4 (4.7mm)	No.10 (2.0mm)	No. 200 (0.074mm)		
1 Persayo-Farb									
Persayo	0-12	Silty clay loam	CL	A-6 or A-7	100	100	70-90	0.2-0.6	Moderate
Farb*	0-14	Sandy loam	SM or ML	A-4	85-95	80-90	45-60	2.0-6.0	Low
Sundown	0-15	Loamy sand	SM	A-3 or A-2	100	100	15-25	> 6.0	Low
	15-29	Sand	SP-SM	A-3 or A-2	100	100	5-15	> 6.0	Low
	29-49	Gravelly sand	SW	A-3 or A-2	70-80	60-70	1-10	> 6.0	Low
	49-60	Sand	SP-SW	A-3 or A-2	100	100	5-15	> 6.0	Low
2 Werlow-Fruitland-Turley									
Werlow	0- 7	Loam	ML	A-4	100	100	60-75	0.6-2.0	Low
	7-12	Fine sandy loam	SM	A-4	100	100	35-50	0.6-2.0	Low
	12-60	Loam	ML or CL	A-4	100	100	55-75	0.6-2.0	Low
Fruitland	0-60	Sandy loam	SM	A-2-4 or A-4	100	100	25-50	2.0-6.0	Low
Turley	0-60	Clay loam	CL or CH	A-6	100	100	70-90	0.2-0.6	Moderate to high
Azfield	0-60	Loam	ML	A-4	100	100	45-75	0.6-2.0	Low
3 Doak-Shiprock									
Doak	0- 5	Loam	ML	A-4	100	100	60-75	0.6-2.0	Low
	5-17	Clay loam	CL	A-6	100	100	75-90	0.6-2.0	Moderate
	17-60	Clay loam	CL	A-6	100	100	70-90	0.6-2.0	Low
Shiprock	0- 4	Fine sandy loam	SM	A-4	100	100	35-50	2.0-6.0	Low
	4-13	Sandy clay loam	ML	A-4	100	100	45-55	0.6-2.0	Low
	13-60	Fine sandy loam	SM	A-2-4	100	100	25-35	2.0-6.0	Low
Grandview	0-39	Loam	ML	A-4	100	100	60-75	0.6-2.0	Low
	39-60	Very fine sandy loam	ML	A-4	100	100	45-60	0.6-2.0	Low
4 Shiprock-Sheppard									
Shiprock	0- 4	Fine sandy loam	SM	A-4	100	100	35-50	2.0-6.0	Low
	4-13	Sandy clay loam	ML	A-4	100	100	45-55	0.6-2.0	Low
	13-60	Fine sandy loam	SM	A-2-4	100	100	25-35	2.0-6.0	Low
Sheppard	0-60	Loamy sand	SM or SP-SM	A-3 or A-2	100	100	5-20	2.0-10	Low
Nageesi	0-12	Sandy loam	SM	A-2-4	100	100	25-40	2.0-6.0	Low
	12-28	Fine sandy loam (limy)	SM	A-4	100	100	35-60	0.6-2.0	Low
	28-44	Sandy loam	SM	A-2-4	100	100	25-40	2.0-6.0	Low
	44-60	Loamy sand	SM	A-1-6	100	100	10-25	> 6.0	Low
5 Hilly-Gravelly Land									
Hilly-Gravelly land		(No estimates made)							
Doak	0- 5	Loam	ML	A-4	100	100	60-75	0.6-2.0	Low
	5-17	Clay loam	CL	A-6	100	100	75-90	0.6-2.0	Moderate
	17-60	Clay loam	CL	A-6	100	100	70-90	0.6-2.0	Low
6 Badland-Rock Land									
Badland		(No estimates made)							
Persayo	0-12	Silty clay loam	CL	A-6 or A-7	100	100	70-90	0.2-0.6	Moderate
7 Turley-Badland									
Turley	0-60	Clay loam	CL or CH	A-6	100	100	70-90	0.2-0.6	Moderate
Azfield	0-60	Loam	ML	A-4	100	100	45-75	0.6-2.0	Low
8 Rock Land-Billings									
Billings	0-60	Silty clay loam	CL or ML-CL	A-6 or A-7	100	100	75-90	0.2-0.6	Moderate
Christianburg-like	0-60	Clay	CH	A-7	100	100	75-95	< 0.2	High
	0-14	Fine sandy loam	SM	A-4	90-95	80-90	45-55	2.0-6.0	Low
9 Camborthid-Farb									
Typic Camborthids.	0- 4	Fine sandy loam	SM or ML	A-4	100	100	45-55	2.0-6.0	Low
	4-25	Very fine sandy loam	ML	A-4	100	100	50-75	1.5-2.0	Low
Farb*	0-14	Fine sandy loam	SM or ML	A-4	90-95	80-90	45-60	2.0-6.0	Low
10 Persayo-Billings									
Persayo	0-12	Silty clay loam	CL	A-6 or A-7	100	100	70-90	0.2-0.6	Moderate
Billings	0-60	Silty clay loam	CL or ML-CL	A-6 or A-7	100	100	75-90	0.2-0.6	Moderate
Christianburg-like	0-60	Clay	CH	A-7	100	100	75-95	< 0.2	High

11 Persayo-Rock Land									
Persayo	0-12	Silty clay loam	CL	A-6 or A-7	100	100	70-90	0.2-0.6	Moderate
Typic Camborthids.	0- 4	Fine sandy loam	SM or ML	A-4	100	100	45-55	2.0-6.0	Low
	4-25	Very fine sandy loam	ML	A-4	100	100	50-75	1.5-2.0	Low
12 Chipeta-Sheppard-Shiprock									
Chipeta	0-15	Clay	CH	A-7	100	100	75-90	< 0.2	High
Sheppard	0-60	Loamy sand	SM or SP-SM	A-3 or A-2	100	100	5-20	2.0-10.	Low
Shiprock	0- 4	Fine sandy loam	SM	A-4	100	100	35-50	2.0-6.0	Low
	4-13	Sandy clay loam	ML	A-4	100	100	45-55	0.6-2.0	Low
	13-60	Fine sandy loam	SM	A-2-4	100	100	25-35	2.0-6.0	Low
13 Rock Land-Torriorthent									
Rock Land		(No estimates made)							
Lithic Torriorthents	0- 4	Gravelly loam	ML	A-4	75-95	70-90	55-75	0.6-2.0	Low
	4- 7	Loam	ML	A-4	100	100	60-75	0.6-2.0	Low
	7-15	Clay loam	CL	A-6	100	100	70-80	0.6-2.0	Moderate
14 Travessilla-Rock Land									
Travessilla*	0-15	Sandy loam	SM	A-4 or A-2-4	90-95	80-90	25-50	2.0-6.0	Low
Ustic Torriorthents	0-15	Silty clay loam	CL	A-6 or A-7	100	100	70-90	0.2-0.6	Moderate
Del Rio	0- 7	Loam	ML	A-4	100	100	75-90	0.6-2.0	Low
	7-37	Clay loam	CL	A-6	100	100	75-90	0.2-0.6	Moderate
	37-60	Clay loam	CL	A-6	100	100	70-85	0.6-2.0	Moderate
15 Del Rio-Silver									
Del Rio	0- 7	Loam	ML	A-4	100	100	75-90	0.6-2.0	Low
	7-37	Clay loam	CL	A-6	100	100	75-90	0.2-0.6	Moderate
	37-60	Clay loam	CL	A-6	100	100	70-85	0.6-2.0	Moderate
Silver	0- 8	Loam	ML	A-4	100	100	70-90	0.6-2.0	Low
	8-30	Silty clay loam or clay	CH or MH	A-7	100	100	75-95	0.2-0.6	High
	30-60	Clay loam	CL	A-6	100	100	70-80	0.2-0.6	Low
Travessilla	0-15	Sandy loam	SM	A-4 or A-2-4	90-95	80-90	25-50	2.0-6.0	Low
16 La Fonda-Del Rio									
La Fonda	0- 4	Loam	ML	A-4	100	100	60-75	0.6-2.0	Low
	4-16	Heavy loam	ML-CL	A-4	100	100	60-80	0.2-2.0	Low-Moderate
	16-60	Loam	ML	A-4	100	100	60-75	0.6-2.0	Low
Del Rio	0- 7	Loam	ML	A-4	100	100	75-90	0.6-2.0	Low
	7-37	Clay loam	CL	A-6	100	100	75-90	0.2-0.6	Moderate
	37-60	Clay loam	CL	A-6	100	100	70-85	0.6-2.0	Moderate
17 Travessilla-Malposa-Rock Land									
Travessilla	0-15	Sandy loam	SM	A-4 or A-2-4	90-95	80-90	50-75	2.0-6.0	Low
Malposa*	0- 5	Stony loam	LM or SM	A-4	60-70	40-60	50-75	0.6-2.0	Low
	5-16	Stony clay loam	CL	A-6	70-85	60-70	50-75	0.2-0.6	Moderate
	16-30	Stony loam	ML or CL	A-4 or A-6	60-75	40-60	50-75	0.6-2.0	Low
18 Vamer-Rock Land									
Vamer*	0- 4	Loam and cobbly loam	ML	A-4	100	90-100	50-75	0.6-2.0	Low
	4-15	Clay	CH	A-7	100	100	75-95	< 0.2	High
	15+	Sandstone							
Typic Eutroboralfs, steep phase	0-11	Loam	ML	A-4	100	100	60-75	0.6-2.0	Low
	11-25	Loamy fine sand	SM	A-2	100	100	15-25	> 6.0	Low
	25-30	Sandy clay loam	ML or CL	A-4 or A-6	100	100	35-60	0.6-2.0	Low-Moderate
	30-60	Very fine sandy loam	SM or ML	A-4	100	100	45-60	0.6-2.0	Low
Typic Eutroboralfs, gently sloping	0-24	Loam	ML	A-4	100	100	60-75	0.6-2.0	Low
	24-30	Very fine sandy loam	SM or ML	A-4	100	100	45-60	0.6-2.0	Low
	30-36	Sandy clay loam	ML or CL	A-4 or A-6	100	100	35-50	0.6-2.0	Low
	36-60	Very fine sandy loam	SM or ML	A-4	100	100	45-60	0.6-2.0	Low

*These soils usually contain coarse fragments greater than 3 inches.

Table 7. Interpretation of soil properties for engineering uses, San Juan County, New Mexico

Soil Map Symbol and Soil Association	Suitability as a Source of— Topsoil	Road fill	Degree of Limitation for Septic Tank Filter Fields	Corrosion Potential (untreated steel pipe)
1 Persayo-Farb				
Persayo silty clay loam	Poor; erodible	Poor	Severe; shallow to shale; slow permeability	High
Farb sandy loam	Poor; low fertility; erodible	Fair; material very limited	Severe; shallow to sandstone	Low
Sundown loamy sand	Poor; sandy and erodible	Good if soil binder is added	Slight	Low
2 Fruitland				
Fruitland loam	Surface 10-12 inches good; subsoil fair	Fair	Moderate; overflow and water table may be problems	Moderate
Fruitland sandy loam	Fair; moderately sandy	Good	Slight	Low
Turley clay loam	Poor; erodible high clay content	Poor	Severe; slow permeability	Moderate to high
Azfield loam	Surface 6 to 10 inches good; subsoil fair	Fair	Moderate	Low to moderate
3 Doak-Shiprock				
Doak loam	Fair	Fair	Moderate; permeability moderately slow	Low to moderate
Shiprock fine sandy loam	Poor; sandy and erodible	Good	Slight	Low
Grandview loam	Fair	Fair to good	Moderate; permeability moderate	Moderate
4 Shiprock-Sheppard				
Shiprock fine sandy loam	Poor; sandy and erodible	Good	Slight	Low
Sheppard loamy sand	Poor; very sandy and erodible	Good if soil binder is added	Slight	Low
Nageesi sandy loam	Poor; sandy and erodible	Good	Slight	Moderate
Typic Camborthids	Poor; sandy and erodible	Good if soil binder is added	Slight	Low
5 Hilly-Gravelly Land				
Hilly gravelly land	(Interpretations not made)			
Doak loam	Fair	Fair	Moderate; permeability moderately slow	Low to moderate
Grandview	Fair	Fair to good	Moderate; permeability moderate	Moderate

Soil Features Affecting—				
		Farm ponds		
oundation support	Highway location	Reservoir area	Embankment	Terraces, diversions, contour furrows, and pitting
oor bearing capacity; allow to shale; low ear strength	Shallow to shale; unstable material; very erodible; moderate slopes	Subject to seepage; shallow to shale; saline	Poor stability; subject to cracking	Unstable embankments channels subject to siltation; difficult to vegetate
ndstone at depths 10 to 20 inches	Shallow to sandstone; outcrops of sandstone; moderate slopes	Shallow; subject to seepage	Limited soil material; moderate permeability	*
*	Good; moderately erosive when exposed on embankments	Poor; very rapidly permeable	Erodible and permeable	Erodible; sandy and porous material difficult to vegetate
ater table and overflow ay be problems	Occasional high water tables and seep areas	Moderate permeability; sandy stratas may require sealing	Stable material when compacted	Features generally favorable; some seep areas
*	**	Rapidly permeable; subject to seepage	Erodible; fair if compacted	Erodible and permeable; fairly stable if compacted
oor bearing capacity hen wet; moderate to gh shrink-swell	Plastic material; poor bearing capacity when wet	Good; low permeability	Difficult to work; plastic when wet; erodible	Erodible; difficult to vegetate; subject to channel erosion
*	**	Good with compaction	Stable material when compacted	**
oderate shrink-swell d bearing capacity nen wet	Moderately plastic and moderate bearing capacity when wet	Good; slowly permeable subsoil	Stable material when compacted	Subsoil material subject to cracking and difficult to vegetate
*	**	Rapidly permeable	Erodible; fair if compacted	Erodible; very permeable
	**	High lime content; requires compaction	Exposed limy material erodible and difficult to vegetate	Exposed limy material erodible and difficult to vegetate
	**	Rapidly permeable	Erodible; fair if compacted	Erodible; very permeable
l features favorable cept under-cutting by nd erosion	Wind erosion and drifting sand	Material too porous to hold water	Erodible and very permeable	*
	Limy materials difficult to vegetate when exposed	Rapidly permeable	Erodible; fair if compacted	Erodible; exposed limy materials difficult to vegetate
	Moderately erosive when exposed on embankments	Poor; very rapidly permeable	Erodible and permeable	*
derate shrink-swell d bearing capacity en wet	Moderately plastic and moderate bearing capacity when wet	Good; slowly permeable subsoil	Stable material when compacted	Subsoil material subject to cracking and difficult to vegetate
*	**	High lime content; requires compaction	Exposed limy material erodible and difficult to vegetate	Exposed limy material erodible and difficult to vegetate

Table 7. Interpretation of soil properties for engineering uses, San Juan County, New Mexico

Soil Map Symbol and Soil Association	Suitability as a Source of— Topsoil	Road fill	Degree of Limitation for Septic Tank Filter Fields	Corrosion Potential (untreated steel pipe)
6 Badland-Rock Land				
Badland	Poor	Very poor	Severe	High
Rock Land	(Interpretations not made)			
Persayo silty clay loam	Poor; erodible	Poor	Severe; shallow to shale; slow permeability	High
7 Turley-Badland				
Turley clay loam	Poor; erodible high clay content	Poor	Severe; slow permeability	Moderate to high
Azfield loam	Surface 6 to 10 inches good; subsoil fair	Fair	Moderate	Low
8 Rock Land-Billings				
Rock Land	(Interpretations not made)			
Billings silty clay loam	Poor; erodible high silt and clay content	Poor	Severe; slow permeability	Moderate to high
Christianburg-like clay	Poor; high clay content	Poor	Severe; very slowly permeable	High
Farb fine sandy loam	Poor; low fertility; erodible	Fair; material very limited	Severe; shallow to sandstone	Low
9 Camborthid-Farb				
Typic Camborthids	Poor; low fertility; erodible	Fair; borrow material limited	Severe; 20 to 36 inches to sandstone	Low to moderate
Farb sandy loam	Poor; low fertility; erodible	Fair; material very limited	Severe; shallow to sandstone	Low
10 Persayo-Billings				
Persayo silty clay loam	Poor; erodible	Poor	Severe; shallow to shale; slow permeability	High
Billings silty clay loam	Poor; erodible high silt and clay content	Poor	Severe; slow permeability	Moderate to high
Christianburg-like clay	Poor; high clay content	Poor	Severe; very slowly permeable	High
11 Persayo-Rock Land				
Persayo silty clay loam	Poor; erodible	Poor	Severe; shallow to shale; slow permeability	High
Typic Camborthids	Poor; low fertility; erodible	Fair; borrow material limited	Severe; 20 to 36 inches to sandstone	Low to moderate
Rock Land	(Interpretations not made)			
12 Chipeta-Sheppard-Shiprock				
Chipeta clay	Poor; high clay content; erodible	Poor	Severe; shallow to shale; low permeability	High
Sheppard loamy sand	Poor; very sandy and erodible	Good if soil binder is added	Slight	Low
Shiprock fine sandy loam	Poor; sandy and erodible	Good	Slight	Low

Soil Features Affecting—				
		Farm ponds		Terraces, diversions, contour furrows, and pitting
oundation support	Highway location	Reservoir area	Embankment	
oor bearing capacity; w shear strength	Very poor; very shallow to shale: erodible: steep slopes	Subject to seepage; saline; very shallow	Poor stability erodible; saline	*
oor bearing capacity; allow to shale; low ear strength	Shallow to shale; unstable material; very erodible; moderate slopes	Subject to seepage; shallow to shale; saline	Poor stability; subject to cracking	Unstable embankments channels subject to siltation; difficult to vegetate
oor bearing capacity hen wet; moderate to gh shrink-swell	Plastic material; poor bearing capacity when wet	Good; low permeability	Difficult to work; plastic when wet; erodible	Erodible; difficult to vegetate; subject to channel erosion
	**	Good with compaction	Stable material when compacted	**
oor bearing capacity; oderate shrink-swell	Poor stability and bearing value	Cracks when dry; may need compaction	Poor stability; erodible	Subject to cracking on drying; low stability; erodible; subject to channel erosion
oor bearing capacity; gh shrink-swell tential	Poor stability and bearing value; high shrink-swell	Good; very slowly permeable	Poor stability; erodible	Subject to cracking on drying; poor stability; erodible; subject to channel erosion and piping
ndstone at depths of to 20 inches	Shallow to sandstone; out-crops of sandstone; moderate slopes	Shallow to sandstone; subject to seepage	Limited soil material; moderate permeability	*
ndstone at depths of to 36 inches	Good stability and bearing value	Subject to seepage; moderately deep to sand-stone	Erodible; moderate per-meability	Erodible; fair stability if compacted
ndstone at depths of to 20 inches	Shallow to sandstone; out-crops of sandstone; moderate slopes	Shallow to sandstone; sub-ject to seepage	Limited soil material; moderate permeability	*
or bearing capacity; allow to shale; low ear strength	Shallow to shale; unstable material; very erodible; moderate slopes	Subject to seepage; shallow to shale; saline	Poor stability: subject to cracking	Unstable embankments channels subject to siltation; difficult to vegetate
or bearing capacity; derate shrink-swell	Poor stability and bearing value	Cracks when dry; may need compaction	Poor stability; erodible	Subject to cracking on drying; low stability; erodible; subject to channel erosion
or bearing capacity; h shrink-swell tential	Poor stability and bearing value; high shrink-swell	Good; very slowly permeable	Poor stability; erodible	Subject to cracking on drying; poor stabllity; erodible; subject to channel erosion and piping
r bearing capacity; llow to shale; low ar strength	Shallow to shale; unstable material; very erodible; moderate slopes	Subject to seepage; shallow to shale; saline	Poor stability; subject to cracking	Unstable embankments channels subject to siltation; difficult to vegetate
dstone at depths of to 36 inches	Good stability and bearing value	Subject to seepage; moderately deep to sandstone	Erodible; moderate permeability	Erodible; fair stability if compacted
r bearing capacity; v sheer strength; h shrink-swell	Shallow to shale; poor sta-bility and bearing capacity; high shrink-swell	Subject to seepage; very shallow to shale; saline	Poor stability; erodible saline	*
features favorable ept under-cutting by d erosion	Wind erosion and drifting sand	Material too porous to hold water	Erodible and very permeable	*
	**	Rapidly permeable	Erodible; fair if compacted	Erodible; very permeable

Table 7. Interpretation of soil properties for engineering uses, San Juan County, New Mexico

Soil Map Symbol and Soil Association	Suitability as a Source of—		Degree of Limitation for Septic Tank Filter Fields	Corrosion Potential (untreated steel pipe)
	Topsoil	Road fill		
13 Rock Land-Torriorthent				
Lithic Torriorthents	Poor; low fertility; gravelly	Fair; borrow material limited	Severe; shallow to bedrock	Moderate
Rock Land	(Interpretations not made)			
14 Travessilla-Rock Land				
Travessilla sandy loam	Poor; sandstone fragments; erodible	Fair; borrow material limited	Severe; shallow to sandstone	Low
Ustic Torriorthents	Poor; high silt and clay content; erodible	Poor; borrow material limited	Severe; shallow to shale	High
Del Rio Loam	Good to a depth of 6 to 10 inches	Poor	Severe; low permeability	Moderate
Rock Land	(Interpretations not made)			
15 Del Rio-Silver				
Del Rio loam	Good to a depth of 6 to 10 inches	Poor	Severe; low permeability	Moderate
Silver loam	Good to a depth of 6 to 8 inches	Poor	Severe; low permeability	Moderate
Travessilla sandy loam	Poor; sandstone fragments; erodible	Fair; borrow material limited	Severe; shallow to sandstone	Low
16 La Fonda-Del Rio				
La Fonda loam	Fair to a depth of 6 to 8 inches	Fair	Moderate; moderate permeability	Low to moderate
Del Rio loam	Good to a depth of 6 to 10 inches	Poor	Severe; low permeability	Moderate
17 Travessilla-Malposa-Rock Land				
Travessilla sandy loam	Poor; sandstone fragments; erodible	Fair; borrow material limited	Severe; shallow to sandstone	Low
Malposa stony loam	Poor; stony	Poor	Severe; shale and sandstone often within 5 feet	Moderate to high
Rock Land	(Interpretations not made)			
18 Vamer-Rock Land				
Vamer loam	Poor; some sandstone fragments; limited depth	Poor borrow material limited; high shrink-swell	Severe; shallow to sandstone	High
Rock Land	(Interpretations not made)			
Typic Eutroboralfs, steep	Good to a depth of 10 to 15 inches	Fair	Severe; steep slopes	Low to moderate
Typic Eutroboralfs, gently sloping	Good to a depth of 20 to 24 inches	Fair	Moderate; moderately permeable; deep to sandstone	Low to moderate

*Unsuitable or practice not applicable.
**Soil features favorable

Soil Features Affecting—				
		Farm ponds		
Foundation support	Highway location	Reservoir area	Embankment	Terraces, diversions, contour furrows, and pitting
Bedrock at 10 to 20 inches	Shallow to bedrock	Subject to seepage; shallow to bedrock	Limited soil material; shallow to bedrock	*
Sandstone bedrock at depths of 10 to 20 inches	Shallow to sandstone; outcrops of bedrock slope	Subject to seepage through fractured sandstone	Limited soil material; erodible	*
Poor bearing capacity and shear strength; shallow to shale	Poor stability and bearing capacity; shallow to shale	Subject to seepage; shallow to shale	Limited fill material; erodible	Unstable embankments; subject to channel erosion and siltation
Fair bearing capacity and shear strength; moderate shrink-swell	Fair stability and bearing value	Good; slowly permeable	Fair stability; impervious	Fairly stable; impervious
Fair bearing capacity and shear strength; moderate shrink-swell	Fair stability and bearing value	Good; slowly permeable	Fair stability; impervious	Fairly stable; impervious
Poor to fair bearing capacity and shear strength; moderate shrink-swell	Fair stability and poor to fair bearing value	Good; slowly permeable	Fair stability; clayey impervious material	Fairly stable; subject to moderate cracking on drying
Sandstone bedrock at depths of 10 to 20 inches	Shallow to sandstone; outcrops of bedrock slope	Subject to seepage through fractured sandstone	Limited soil material; erodible	*
Fair bearing capacity and shear strength	Erodible; embankment materials; fair bearing value	Moderate permeability; good if compacted	Fair stability; subject to moderate channel erosion	Fairly stable; moderately permeable
Fair bearing capacity and shear strength; moderate shrink-swell	Fair stability and bearing capacity	Good; slowly permeable	Fair stability; impervious	Fairly stable; impervious
Sandstone bedrock at depths of 10 to 20 inches	Shallow to sandstone; outcrops of bedrock slope	Subject to seepage through fractured sandstone	Limited soil material; erodible	*
May be subject to slides because of underlying shale and sandstone; fair bearing value	Steep slopes; stony; shale and sandstone often within 5 feet; rock outcrops	*	*	*
Shallow to sandstone	Moderate slopes; shallow to sandstone; occasional outcrops of bedrock	Shallow; subject to seepage	Borrow material limited; plastic; clayey material	*
Soil features favorable; steep slopes	Steep slopes; some stones and rock outcrops; fair stability and bearing capacity	Moderate permeability; steep slopes	Good stability	*
Fair to good bearing capacity	Surface layers have moderate organic matter; few outcrops of bedrock; few seep areas	Moderate permeability; may require sealing and compaction	Good stability	**

Experiment Station, Corps of Engineers.[8] This system is based on identification of soils according to their texture and plasticity and their performance as engineering construction materials. Soil materials are identified as coarse-grained (8 classes), fine-grained (6 classes), or highly organic.

The estimated percentage of soil material passing sieves No. 4, No. 10, and No. 200 is in the columns headed by these sieve numbers. The percentage of material as given reflects the normal range for the soil series, and most soils within a series will fall within the range indicated.

Permeability as indicated in table 6 relates to the rate water moves through undisturbed and uncompacted soil. The estimates are based on the texture, structure, and porosity of the soil.

Shrink-swell potential is an indication of the volume change to be expected of the soil material with changes in moisture content. Shrinking and swelling of soils cause much damage to building foundations, roads, and other structures. A high shrink-swell potential indicates hazards to the maintenance of structures constructed in, on, or with such materials.

Engineering Interpretations

Table 7 indicates the relative suitability of soils to support various structures, to serve as construction materials for highways, farm facilities, and other engineering structures, to absorb sewage effluent, and to serve for other engineering purposes. Also listed are soil features or properties that might present difficulties or affect such uses. Although soil features restricting the use of soils for various engineering structures are emphasized, favorable soil features may also be listed. The ratings and other interpretations in this table are based on the estimated soil properties for engineering uses as listed in table 6, on available test data, and field experience.

Topsoil is a term used to designate a fertile soil or soil material of favorable texture, structure, and organic matter content used as a topdressing for lawns, roadbanks, and various other engineering structures. The ratings of poor, fair, or good indicate the general suitability of the surface soil layers for such use.

Suitability ratings of poor, fair, or good for road fill are given for the major soils in each soil association. The ratings are based on the performance of the soil material when excavated and used as borrow for highway subgrade.

Sewage fields are affected mainly by permeability, depth of water table, depth of bedrock or indurated caliche, and susceptibility to flooding. The degree of limitations and principal reasons for assigning moderate or severe limitations are given.

A corrosion potential of low, moderate, or high is indicated for the major soils in each soil association. Corrosivity, as used here, indicates the potential danger of uncoated steel pipe to corrode or become weakened through chemical action. Among the features considered in rating corrosion potential are soil drainage, presence of soluble salts, and frequency of wetting and drying. The texture, structure, and porosity of the soil are also important because of their effect on aeration, moisture-holding capacity, and water movement.

In the remainder of the columns in table 7 are given the major soil features or properties that affect the use of a soil for specified purposes. For example, under the column headed "Foundation Support" are listed those features of the undisturbed soil that influence its capacity to support low buildings with normal foundation loads. Although specific values of bearing capacity and shear strength are not assigned, general values are indicated.

Highway location is influenced by features of the undisturbed soil that affect construction and maintenance of highways. The soil features considered include the depth to bedrock and caliche, the content of stones and rocks, the suitability for embankments, susceptibility to overflow, erodibility, stability, ease of excavation and hauling, salinity, plasticity, and topography. The more common soil features affecting highway construction and maintenance are listed in the column headed "Highway Location."

The soil features that affect seepage or loss of water from excavated reservoir sites are those considered under farm pond reservoir areas. The permeability, depth to bedrock or caliche, and possibility of exposing porous strata are some of the items listed.

Farm pond embankments serve as dams. The major soil features, of both subsoil and substratum, that are of importance in the use of soils for constructing embankments are considered.

Terraces and diversions are low structures designed to retain or direct water. Pitting, chiseling, and contour furrowing serve to loosen the soil and retain water from rainfall and snow melt. The intake rate, permeability, stability of clods, and the use of the soil material for embankments are the soil features considered.

8Waterways Experiment Station, Corps of Engineers. 1953 the Unified Soil Classification System. Tech. Memo. 3-357. 2 V. and appendix.

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